

**SOUTH CAROLINA
STATE BOARD OF DENTISTRY**

STUDY GUIDE

for the

DENTAL TECHNICIAN EXAMINATION

This Study Guide is a summary of information that comes directly from VOLUME I – DENTAL LABORATORY TECHNOLOGY BASIC SCIENCES, U.S. Department of the Air Force, a foundation text for the U.S. Air Force Dental Laboratory Specialist Course. It is intended to assist candidates in preparation for the South Carolina State Board Dental Technician Examination.

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INFECTION CONTROL TERMINOLOGY

Antiseptic – Chemical agent applied to a tissue to inhibit the growth of microorganisms.

Asepsis – A pathogen-free condition.

Dental Item Classification – Dental items can be classified as critical, semicritical, or non-critical in their need for sterilization or various levels of disinfection. These classifications are determined by where and how the items are used:

- (a) **Critical Items** – Objects that enter the skin, mucous membrane, or vascular system and present the greatest risk of infection. Critical items must be sterile PRIOR to use, for example, scalpel blades, hypodermic needles, surgical instruments, and suture needles.
- (b) **Semicritical Items** – Objects that frequently contact mucous membranes and are often contaminated by oral secretions and blood, but that do not enter the tissue or vascular systems. These items must have high to intermediate level disinfection, for example, shade guides, facebows, jaw relationship records, impressions, and prosthetic devices.
- (c) **Noncritical Items** – Objects that don't ordinarily contact mucous membranes or broken skin. These items should have intermediate to low level disinfection, for example, receiving areas, case pans, and articulators. The term noncritical does not imply nonimportance.

Disinfection – The destruction or inhibition of most pathogenic bacteria while they are in their active growth phase and the inactivation of some viruses are termed disinfection. In most cases the disinfecting process does not kill spores and cannot be easily verified. In addition to their normal spectrum, disinfectants used in a dental clinic environment also need to be tuberculocidal. The Environmental Protection Agency (EPA) is tasked with classifying sterilants and disinfectants, which are sporicidal, as sterilizing agents. Defined levels of disinfection are based on the biocidal activity of an agent against bacterial spores, tubercle bacilli, an agent against bacterial spores, tubercle bacilli, vegetative bacteria, and viruses; and the contact time of the solution.

- (a) **High Level Disinfectants (Sterilizing Agents)** – Are biocidal against all classes of microbes and they are used for all critical and some semicritical items.
- (b) **Intermediate Level Disinfectants** – These agents will not routinely kill spores but they are biocidal against all other classes. Intermediate level disinfectants are used for semicritical and some noncritical items.

- (c) **Low Level Disinfectants** – These agents are not effective against either tubercle bacilli, bacterial spores, or certain nonlipid viruses. Low level disinfectants are used only for noncritical items.
- (d) **High-Risk Patient** – An individual who, because of physical condition, medical treatment, or lifestyle, is physiologically compromised and has a high potential for carrying and transmitting pathogenic microorganisms.

Sanitation – The process of totally destroying all forms of life within an environment, including viruses and spores. Heat sterilization can be monitored and verified; however, the sterilization by high level disinfectant solutions cannot be easily monitored or verified.

Unit Dose – Dispensing only those materials or supplies required for treating a single patient.

LABORATORY INFECTION CONTROL

Laboratory personnel can be protected against infection by establishing a barrier system. In practice, this means sterilizing or disinfecting dental items that have had contact with the patient before and after any laboratory work is performed. With an operational barrier system, a prosthesis can be processed in the laboratory without the need to disinfect or sterilize laboratory instruments and equipment following each use. Suggested infection control procedures for the laboratory are:

1. **Impressions Brought Into the Laboratory:**
 - (a) **Impressions.** Under running tap water, rinse impressions thoroughly before pouring your cast.
 - (b) **Impression Trays.** Scrub reusable trays in soapy water and seal them in 4-inch transparent tubing. Sterilize trays in a steam or chemical vapor sterilizer. If the trays are to be hung in a cabinet, place two heat seals an inch apart at the top of the tape and punch a hole between the seals. The tray can be hung for an extended period of time without compromising sterility. A dental assistant normally packages and sterilizes the trays.
2. **Saturated Calcium Sulfate Dihydrate Solution (SDS).** Prepare SDS from fresh-set stone that has never been poured against a potentially contaminating impression.
3. **Prosthesis Brought Into the Laboratory:**

- (a) **Initial Preparation.** Using a bacteriocidal soap and a brush, scrub all prosthetic devices. Between uses, store the brush in a cold sterilant solution, replacing the solution as recommended by the manufacturer.
 - (b) **Cleaning Prosthesis.** After scrubbing, place the prosthesis into a disinfectant-filled container. Place the container into an ultrasonic cleaner for up to 10 minutes, depending on the manufacturer's instructions. Cover the ultrasonic cleaner to reduce aerosol spread into the laboratory area. Change solutions when they are visibly dirty. In an area dental laboratory facility that does not have direct in-house communication with patient care, disinfect all repairs and returned appliances before they are entered into the laboratory.
4. **Dispensing the Finished Product.** Scrub and ultrasonically treat the finished prosthesis, as in (b) above, prior to sending it out of the laboratory.
5. **Case Pans.** Between cases, use an acceptable disinfectant to wipe out pans.
6. **High-Risk Patients.** Keep those appliances or impressions from high-risk patients separate from other lab work. Wear surgical gloves and a mask when handling these materials. Sterilize all instruments and devices that come in contact with a high-risk patient's prosthesis or impression.
7. **Rush Cases.** Do not allow rush cases to jeopardize the barrier system. If a prosthesis is adjusted or modified in the dental treatment room and additional laboratory support is required, make one of these two choices: Recognize that, depending on the disinfectant, up to a 20-minute turn-around time is required or utilize the "barrier system" to protect the dental laboratory. If this is not possible, establish a unit-dose polishing area that is physically removed from the dental laboratory. In the isolated area, include a polishing unit, individually wrapped wheels, abrasive points, and polishing agents. Enclose catch pans for pumice in sealed plastic bags for single patient use.

PROPER HANDWASHING

Hands must be thoroughly washed and free of jewelry to remove resident bacteria and transient organisms acquired from contact with patients or contaminated surfaces. All personnel involved with patient care must follow a rigid handwashing policy:

1. **Initial Hand Cleansing.** Cleanse hands at the beginning of each duty day.
 - (a) **Preliminary Considerations.** Remove all rings, fingernails should be free of nail polish, trimmed and cleaned using a nail-cleaner. Do not wear false fingernails as contamination may occur from fungal growth occurring between the false and natural nail.

- (b) **Handcleaning Steps.** Wet your hands, apply an antiseptic solution, and scrub your hands and nails with a surgical sponge or brush. Rinse thoroughly because some antiseptic hand cleaning agents may irritate your skin if they are not thoroughly removed. Finally, dry your hands using a clean paper towel.
- (c) **Repeat Hand Cleaning.** Repeat handcleansing is required after you work with contaminated dental items, before you have lunch, and before you leave the dental clinic.

CHEMICAL STERILIZATION AND DISINFECTION

Although heat sterilization is the preferred method, certain instruments and many dental materials cannot be placed in a heat sterilizer; they require chemical sterilization or disinfection.

1. **Chemical Sterilization:**

- (a) **Glutaraldehyde.** Three types of glutaraldehyde are available: alkaline, neutral, and acidic. Most formulations contain 2 percent glutaraldehyde and come in two containers. When the proper amounts from each container are mixed, the solution is activated. Glutaraldehyde sterilization cannot be verified by using sterilization monitors. Because it is caustic to the skin, you should use forceps or rubber gloves when you handle prostheses that have been immersed in glutaraldehyde. A 2 percent, room-temperature solution of alkaline or neutral glutaraldehyde should be used to sterilize heat-sensitive items. You need to read the manufacturer's directions carefully because some formulations cannot be used on carbon-steel instruments. Immersion for 6 $\frac{3}{4}$ to 10 hours in a fresh solution of alkaline or neutral glutaraldehyde usually achieves sterilization; however, metallic items cannot be left in any glutaraldehyde solution for longer than a 24-hour period. After activation, the shelf life and reuse life of each solution may vary depending on the formulation. You should place an expiration date on each container of fresh solution to ensure only active solutions are used. Acidic glutaraldehydes that are heated to 60 degrees C in a closed system sterilize instruments in 1 hour. The need for frequent heating and a closed system to eliminate toxic vapors make using acid glutaraldehyde impractical for sterilization.
- (b) **Chlorine Dioxide.** This new chemical sterilant has been approved by the Environmental Protection Agency (EPA). It contains no glutaraldehyde. Chlorine dioxide is economical to use and is nontoxic, nonsensitizing, and nonstaining. It is safe to use on most nonmetal items. It is very corrosive to nonstainless steel metal instruments. It requires an immersion time of 6

hours for sterilization. After activation, it has a shelf life of 14 days, but a reuse life of only 1 day.

- (c) **Ethylene Oxide**. Ethylene Oxide is the most reliable agent for chemical sterilization. It sterilizes objects that are heat labile without producing rust or corrosion. Like heat sterilization, it can be verified with biological spore monitors. Monitoring with *B subtilis* spore should be performed with each sterilization cycle. Certain disadvantages preclude the routine use of ethylene oxide in the dental laboratory. It is very slow acting, taking 4 to 6 hours to complete sterilization. Certain sterilized items retain ethylene oxide gas. They must be aerated for a minimum of 12 hours before they can be used in the oral cavity. There is some concern whether ethylene oxide vapors may be mutagenic and/or carcinogenic. Ethylene oxide must be used according to Occupational Safety and Health Administration (OSHA) standards.

2. **Chemical Disinfection:**

Many different chemical disinfectants are available with varying degrees of effectiveness. It is important to remember that disinfectants can be rendered ineffective by soiled or heavily contaminated prostheses; adequate debridement and cleaning are a prerequisite for effective disinfection. The American Dental Association (ADA) Council on Dental Therapeutics recommends five disinfectants; iodophor, glutaraldehyde; phenolic, chlorine, and formaldehyde compounds. Formaldehyde compounds are usually used as surface or immersion disinfectants in dentistry.

- (a) **Iodophor** – Iodophor compounds contain 0.05-1.6 percent iodine and surface-active agents, usually detergents, which carry and release free iodine. The antimicrobial activity of the iodophor is greater than that of iodine alone. Because the vapor pressure of iodine is reduced in the iodophor, its odor is not as offensive. Also, iodophors do not stain as readily as iodine. Intermediate levels of disinfection can be achieved after 10 to 30 minutes of contact. Iodophors are EPA approved as effective when diluted 1:213 with water. Antiseptic iodine compounds approved by the Federal Drug Administration (FDA) must not be used as disinfectants.
- (b) **Glutaraldehyde** – The types of glutaraldehydes used for disinfection are the same as for sterilization, but their usages differ. Usually a 10-minute immersion in glutaraldehyde provides an intermediate level of disinfection. The label states shelf life, after activation, and reuse life and dilution factors. Glutaraldehydes are best used as immersion disinfectants. It is not practical to use glutaraldehydes as surface disinfectants. Surfaces wiped down with glutaraldehyde must have the residual disinfectant film wiped off with sterile water.

- (c) **Phenolic Compounds** – Synthetic phenolics have also been accepted as disinfectants. In high concentrations, phenolics are protoplasmic poisons. In low concentrations, they inactivate essential enzyme systems. As disinfectants, phenolics are usually combined with a detergent. Some phenolic compounds have also been shown to be bacteriocidal, fungicidal, virucidal, and tuberculocidal.
- (d) **Chlorine.** Chlorine is available as sodium hypochlorite (common household bleach) or as chlorine dioxide. Chlorine containing compounds, if improperly used, can cause corrosion of dental instruments and materials.
- 1) **Sodium Hypochlorite.** Sodium hypochlorite is thought to oxidize microbial enzymes and cell-wall components. A 10 percent solution (1 part bleach to 5 parts water) yields 10,000 parts-per-million of available chlorine which achieves an intermediate level of disinfection in 30 minutes. Because a sodium hypochlorite solution tends to be unstable, a fresh solution must be prepared daily. It possesses a strong odor and can be harmful to eyes, skin, colored clothing, and metals.
 - 2) **Chlorine Dioxide** – Chlorine dioxide is a new chemical disinfectant which the EPA has approved. It is biodegradable, it does not stain your hands or equipment, and does not have to be wiped off environmental surfaces. If it is used within 24 hours of preparation, it requires an immersion time of only 1 minute to achieve an intermediate level of disinfection. Three minutes of immersion or wetting are required if the solution is used 24 or more hours after its preparation. It has a shelf life, after activation, of 14 days and a reuse life of 24 hours.

DENTAL MATERIALS

Gypsum Materials

Gypsum is the common name for *calcium sulfate dihydrate*. Gypsum products are more frequently used in laboratory procedures than any other single group of compounds. Controlled variations in the manufacture of gypsum products yield a group of dental materials including plaster, artificial stone (hydrocal), die stone, casting investment, and soldering investment. Each substance is a carefully formulated powder which has the particular combination of physical properties to do a specific job. When the prepared powder is mixed with the proper amount of water, the blend initially forms a fluid paste which gradually hardens into a solid. In the fluid paste state, the mixture can be poured into molds or otherwise shaped. As gypsum sets, dense masses of crystals form, and heat is liberated. The liberation of heat, called an exothermic reaction, happens while all gypsum products are setting.

Physical Properties of Gypsum Materials.

- a. **Crushing Strength** – Crushing strength or compressive strength is the measure of the greatest amount of compressive force which can be applied to a substance without causing it to fracture. The strength of a gypsum product increases rapidly as it hardens. Because the relative amount of water left in the set material has a distinct effect on strength, two kinds of gypsum product strengths are recognized:
 - 1) **Wet Strength**. The strength of the material with excess water still present in the set-up mass.
 - 2) **Dry Strength**. The strength of a dried gypsum specimen. Twenty-four hours after setting, the compressive strength of a gypsum specimen left to dry is observed to double.
- b. **Setting Time** – Setting time is the time required for the material to set or harden. It is divided into two stages:
 - 1) **Initial Set**. The time that starts when the powder is mixed with water and ends when the material becomes solid enough to handle.
 - 2) **Final Set**. The time required for full crystalization to occur. All exothermic heat dissipates and the mass reaches about half its potential crushing strength.
- c. **Gypsum Expansion:**
 - 1) **Setting Expansion**. A gypsum product enlarges in volume as it sets. This enlargement is called setting expansion and usually

amounts to a fraction of a percent. A gypsum material sets up in air or in contact with water. The setting expansion varies depending on the conditions to which the material is exposed.

- a) **Normal Setting Expansion.** A gypsum product expands predictably when it is allowed to solidify, unconfined in a normal room temperature environment. A setting expansion that takes place under these conditions is called normal setting expansion.
 - b) **Hygroscopic Setting Expansion.** Hygroscopic setting expansion occurs when a gypsum material is allowed to solidify under water. A hygroscopic expansion can be expected to be greater than a normal setting expansion. In some dental procedures, a gypsum product solidifies in limited contact with water, for example, an investment is sometimes made to set against a wet ring liner. The expansion is greater than the normal setting expansion, but it is not as great as a hygroscopic expansion. A setting expansion that occurs as a result of limited contact with water is called semihygroscopic expansion.
- 2) **Thermal Expansion.** This kind of expansion occurs as a result of a gypsum product being heated. The amount of thermal expansion is proportional to the temperature.

Plaster of Paris

- a. **Manufacturing Process.** Gypsum is converted into plaster by grinding it into small particles and then heating it slowly in open vats to drive off the water of hydration. Under a microscope, the plaster is seen to be made up of tiny crystals. Each crystal contains a definite proportion of water. This is called water of crystallization or water of hydration. The amount of water eliminated by heating has a bearing on the behavior of the plaster when it is again mixed with water in the laboratory. A special process is used to ensure that plaster made for dental use has suitable working properties. These properties must always be uniform throughout a batch of material and from one batch of material to another. One of the most important requirements of plaster is that it must set or harden within definite time limits. The amount of setting expansion must also be low.
- b. **Plaster's Role.** Plaster has many uses in the laboratory. It is used for pouring a cast, constructing a matrix, flasking a denture, attaching casts to an articulator, and as an ingredient of some investments. It is used in the dental clinic for several types of mouth impressions. The initial setting

time for most dental plasters is from 7 to 12 minutes. The final setting time is approximately 20 to 45 minutes.

Hydrocal (Artificial Stone). Chemically, hydrocal is very similar to plaster of paris. The method of manufacturing stone is different, and the two differ in some of their physical properties. If you compare hydrocal and plaster under a microscope, you can clearly see that the plaster particle is irregular in shape, and quite porous. The hydrocal particle is prismatic, more regular in shape, and relatively nonporous. For this reason, hydrocal requires less water in mixing and sets more slowly. When set, it is harder, much more dense, and has a higher crushing strength. These properties make it preferable to plaster for master casts in complete and partial denture construction. Hydrocal has many dental uses. The most common uses are fabricating casts and flasking procedures. The manufacturer colors hydrocal to make it easy to distinguish from plaster. The initial setting time of a typical hydrocal product is from 8 to 15 minutes. The final set takes approximately 45 minutes.

Die Stone (Improved Stone). Improved stones are specially processed forms of hydrocal which are used to make crown, onlay, and inlay dies. They are harder, more dense, and have less setting expansion than ordinary hydrocal. They are usually colored to distinguish them from plaster or ordinary hydrocal. Since the amount of setting expansion is critical, it is important to use the water-to-powder ratio the manufacturer recommends.

Investment Materials. Investments are those products used to form molds for molten metal and to relate pieces of metal to one another prior to soldering. Investments are composed of a refractory (heat-resistant) substance like cristobalite or quartz, and a binder. The common binders are gypsum, phosphate, and silicate compounds. As a result, investments are often described as gypsum, phosphate, or silicate bound:

- a. Investments with a high cristobalite content expand more than those with a high percentage of quartz. Since casting investments are supposed to expand significantly to compensate for metal shrinkage, their refractory component contains a lot of cristobalite. Low expansion is a requirement for soldering investments; the refractory component would probably be high in quartz.
- b. Investments are supposed to withstand heat without decomposing. Depending on the binder, investments become more or less able to resist heat-induced breakdown. Overheated, gypsum bound investments liberate sulfur dioxide which makes a casting brittle. To minimize sulfur dioxide liberation, gypsum bonded investment molds are supposed to burn out below 1300 degrees F; also, molten metals thrown (cast) into those molds should have casting temperatures below 1950 degrees F. The company that produces Ticonium chrome alloy makes a special gypsum bound investment that withstands a 1350 degrees F burnout temperature and a casting temperature of 2600 degrees F. Barring this kind of exception,

phosphate and silicate bound investments have excellent high heat resistance and are commonly used when casting or soldering temperatures exceed 1950 degrees F.

Inlay Investment. Inlay investments are gypsum bound. They are commonly used for investing many different kinds of fixed restorations for casting in conventional golds. When molten gold alloy is cast into a mold, it cools and solidifies. As it cools, it shrinks. The amount of shrinkage is approximately 1.4 ± 0.2 percent. If nothing is done to compensate for this shrinkage, the casting will be too small. The mold space must be enlarged so the molten metal is cast into a space that is 1.4 percent oversize. As the molten metal solidifies and shrinks, the casting attains the correct size. Techniques have been devised to use setting and thermal expansion characteristics of investments to compensate for cast metal shrinkage. In one method, high heat (1290 degrees F) is used to produce the majority of the required expansion. In another technique, the hygroscopic expansion of the investment is responsible for most of the compensation. Inlay investments tend to fall into two broad categories depending on how they are used.

- a. High heat technique investments.
- b. Hygroscopic technique investments.

Soldering Investment. A soldering investment is similar in composition to a casting investment that has a quartz refractory. An investment with a quartz refractory expands less than one having cristobalite as the heat resistant component. Minimal normal setting expansion is a desirable soldering investment characteristic. A soldering investment does not expand nearly enough to compensate for the shrinkage of molten gold and should not be used for casting purposes. Like casting investments, soldering instruments are made with gypsum or with high-heat binders. The heat resistance of the binder is matched to the anticipated soldering temperature. As a rule of thumb, a soldering procedure that takes place above 1950 degrees F requires an investment with a high-heat binder.

Investments for Chrome Alloys

- a. **High-Heat, Chrome Alloy Investment.** A high-heat, chrome alloy investment is made to withstand a much higher heat than the 1300 degrees F normally used in eliminating wax for casting gold. Such an investment consists of a quartz powder mixed with an ethyl silicate liquid, and is used with the high melting range, chrome alloys (2700 to 2800 degrees F).
- b. **Low-Heat, Chrome Alloy Investment.** A low-heat, chrome alloy investment is gypsum bound and has a silica refractory component. It is similar to the investment used for casting gold. A low-heat, chrome alloy investment is used as part of the system for producing Ticonium chrome alloy castings. Ticonium metal is used throughout the United States Air Force Dental Service for removable partial denture frameworks. The burnout temperature of Ticonium investment molds is 1350 degrees F, and the casting temperature of Ticonium metal is 2500 to 2600 degrees F.

There is a sulfur dioxide liberation problem associated with gypsum bound investments at high burnout or casting temperatures. One way to combat the sulfur dioxide problem is to increase the percentage of refractory material relative to the gypsum binder in an investment formula.

Ticonium metal shrinks 1.7 percent as it solidifies. The investment and burnout techniques are balanced to furnish that amount of expansion in the mold.

Investments for Ceramic Gold Alloys. Gypsum bonded investments are not adequate for casting ceramic golds. The expansion is not high enough and the gypsum decomposes under the high temperatures. Investments containing magnesium oxide and soluble phosphate are used. The dissolved phosphate reacts with magnesium oxide to form a matrix of magnesium phosphate, which binds silica particles together much the same as gypsum binds low-heat investments. Phosphate bound investments are coarse in particle size, heat resistant, strong, and sometimes difficult to remove from castings. The investment is sluggish and sets rather rapidly with a working time of 3 to 4 minutes.

Rules for Handling Gypsum Products

1. Use Clean Equipment
2. Tumble the Contents
3. Add Powder to Water
4. Measure Water and Weigh Powder
5. Mix Well
6. Vacuum Mix
7. Never Add to a Mix
8. Use Good Equipment
9. Do Not Contaminate Materials
10. Know the Material.

DENTAL WAXES

Wax compounds used in dentistry are mixtures of individual ways of natural or synthetic origin. As with all other dental materials, each component in the mixture is selected to give specific properties best suited for the procedure being performed. Depending on the purpose the wax serves, modifiers are included to change the melting range, increase or decrease stickiness, or impart a distinguishing color.

Dental waxes are supplied in various shapes, sizes, colors, and compositions. The laboratory technician must be familiar with their uses and manipulation and must be prepared for variations in the behavior of different waxes supplied by manufacturers.

Most dental waxes fall generally into one of these three functional groups:

1. **Impression Waxes.** These waxes are used primarily by the dentist at the chair. They have low melting points and flow fairly easily at mouth temperatures. They can be distorted very easily and require extreme care

in handling. Examples of impression waxes are corrective wax and jaw movement recording wax.

2. **Pattern Waxes.** These waxes are used by the dentist and the laboratory technician. They are used to form the molds in which prosthodontic restorations are made. Examples of pattern waxes are inlay wax, baseplate wax, sheet casting wax, wire wax, and preformed wax patterns. Almost all of the pattern waxes, with the notable exception of inlay wax, are meant to be used in controlled thickness. Gage is a measure of thickness. The term is applied to the diameters of metal wires and wax forms having circular and semicircular cross sections (for example, wire wax); gage is also used when talking about sheet metal and sheet wax thicknesses.
3. **Processing Waxes.** You will use these waxes primarily for procedures in the fabrication of prosthodontic restorations. Examples are sticky wax, boxing wax, utility wax, blockout wax, and beeswax.

Beeswax. Refined beeswax is supplied in cakes or bars. It is used in molten form (280 to 300 degrees F) as a dip for sealing refractory casts.

Baseplate Wax. Baseplate wax is composed mainly of beeswax, paraffin, and coloring matter. The ingredients are melted together, cast into blocks, and then rolled into sheets. A typical baseplate wax might contain 50 parts of yellow beeswax, 6 parts of gum mastic, 3 parts of prepared chalk, and 4 parts of vermilion.

Inlay Casting Wax. Inlay wax consists of paraffin which makes up the bulk; gum dammar to improve the smoothness in molding and to render it more resistant to flaking and cracking; and carnuba to control the softening point and hardness of the wax.

Ivory or White Wax. Ivory or white wax is an inlay wax containing no color pigment. It is especially useful for waxing acrylic jacket patterns. It does not leave a colored residue in the plaster mold which might discolor the resin of the jacket crown.

Partial Denture Casting Waxes:

- a. **Wax Forms (Round Cross Section, Half-Round Cross Section).** Preformed wax is supplied by the manufacturer in a variety of shapes and sizes suitable for use in constructing the wax pattern for a partial denture framework. Some of the round forms (wire wax) can also be used for spruing fixed prosthetic units.
- b. **Inlay Wax.** When waxing frameworks, inlay wax is primarily used to free flow and carve those parts of the pattern that join preformed components to each other. Inlay wax is also used to sprue patterns.

- c. **Sheet Casting Wax.** Sheet casting wax is very similar to baseplate wax. At room temperature, it possesses the properties of toughness and pliability at room temperature and sufficient tackiness to adhere to the cast and stay where it is placed.

Sticky Wax. Sticky wax is composed of beeswax, paraffin, and a considerable amount of natural resin. The resin gives the wax its adhesiveness and hardness. An important property of sticky wax is that it breaks, instead of bending or distorting, under pressure. This property makes it useful for tasks like joining the parts of a broken denture, or holding together the structural parts of a wrought wire clasp while it is invested for soldering.

Utility Wax. Utility wax is an extremely pliable wax which is marketed in rope form. It is plastic and somewhat tacky at room temperature which makes it usable without heating. Most importantly, it is used for beading impressions before pouring the cast. Utility wax is sometimes used in impression techniques before pouring the cast to build up the impression tray borders.

Boxing Wax. Boxing wax is a specially prepared wax which is supplied in strips about 1 ½ inches wide and 12 inches long. It is primarily used to box impressions. Most boxing waxes do not require heating. They are pliable enough at room temperature to be formed into desired shapes.

Low-Fusing Impression Wax. Low fusing impression wax is specially compounded to flow under controlled pressure in the mouth. It is melted in a water bath and then painted onto the tissue surface of an individual impression tray as a corrective liner for final impressions for both complete and removable partial dentures.

Undercut (Blockout) Wax. Undercut wax has the physical properties which makes it possible to build it up around an abutment tooth and then easily carve it with surveying tools. This wax is produced by combining beeswax, resin, and kaolin. It is usually supplied in small, wide-mouthed jars.

Disclosing Wax. Disclosing wax has a very low fusing range. It flows readily under pressure. It is used to detect points of unequal pressure when seating many kinds of castings. Disclosing wax is melted on the tissue side of a casting. It is then held in place under pressure. The wax flows away from the pressure points and discloses them for corrections.

IMPRESSION MATERIALS

A variety of impressions are made in the dental office. Each variety requires a material of slightly different properties. In complete denture work, a material is needed which accurately registers all the denture-bearing areas. In partial denture work, there is an additional requirement. The material must be capable of registering both tooth and soft

tissue undercuts. In many dental impression procedures, two materials and sometimes even three are used in sequence to take advantage of the most favorable qualities of each.

DENTURE BASE MATERIALS

A great variety of materials have been used over the years to make denture bases. Today, a plastic material is by far the most universally used. The chemical name is methyl methacrylate. The common name is acrylic resin. A considerable amount of refinement and improvement has been made in acrylic resin and in the methods of handling and processing it since it was first introduced in 1937. The manufacturers supply it as either a powder (polymer) and a liquid (monomer) or in the form of a premixed gel. The powder and liquid form is the one most commonly used. When the material is supplied in this form, the technician adds a measured amount of powder to a specific volume of liquid to form a dough. The dough is then packed into the denture mold, and heat is used to cure the denture. Dry heat can be used, but curing in hot water is the most commonly used method. Known as *polymerization*, the cure or hardening of the acrylic resin in the mold takes place by a chemical reaction between the powder and the liquid.

METALS IN DENTISTRY

Ways in Which Metals are Alike. There is no all-inclusive definition for a metal which is entirely satisfactory. However, metals do have certain properties which serve to identify them from non-metals. They possess a metallic luster, are good conductors of heat and electricity, and with the exception of mercury (and one other metal which is rare), they are solids at ordinary temperatures. Some metals are malleable (can be pounded or rolled into sheets), others are ductile (can be drawn into wire), most of them have a fairly high specific gravity (are dense and as a result, heavy) as compared to non-metals.

Ways in Which Metals are Different. Each metal possesses physical properties peculiar to it alone, which distinguishes it from all other metals. It has a fixed melting point, a definite specific gravity, and a certain degree of hardness, malleability, ductility, etc. By knowing these physical properties, you can predict with a fair degree of accuracy the way the metal behaves under different conditions. In like manner, you may also predict its degree of usefulness as a dental restoration or as a structural part of a prosthesis.

Structure of Metals.

- a) **General Properties.** Metals are crystalline in structure and many of their physical properties depend to a large extent on the size and arrangement of the crystals. The word grain is a very popular name for a metallic crystal. As molten metal cools and solidifies, grains form around nuclei of crystallization. The faster a molten metal cools to the solid state, the

smaller will be the grain size and vice versa. Generally speaking, small grains arranged in an orderly fashion give the most desirable properties. The size and arrangement of grains can be changed markedly by the way in which the metal is handled in the laboratory. The amount of heat to which a metal is subjected, the method by which it is heated, the rate it is cooled, and the way it is worked (for example, bending or swaging), all have a pronounced effect on its physical properties.

- b) **Cast Metal.** A cast metal is a piece of metal formed by pouring or forcing molten metal into a mold and allowing it to cool and harden. As stated, the size of the grains in a casting depends on the rate of cooling before and during solidification. The shape and arrangement of the grains are also established at the same time.
- c) **Wrought Metal.** When the shape of a casting is changed by rolling, pounding, bending, or twisting, it becomes a wrought metal. Producing changes in the shape of a metal at normal room temperature is called cold working. Working a metal changes its grain structure and has a marked and sometimes detrimental influence on the physical properties of the material. You must have a thorough understanding of the changes taking place in the metal you work so you can control and, if necessary, correct them.
- d) **Metal Alloys.** Some of the properties of a given metal might be ideal for a specific use while other properties of the same metal might be less desirable, or even detrimental. By combining several metals in the correct proportions, it is possible to produce a compound in which the desirable properties of each metal are retained, while the less desirable ones are nullified or entirely eliminated. This is known as *alloying*, and the combination of metals thus formed is a metal *alloy*. The physical properties of an alloy cannot be accurately predicted solely on the basis of a knowledge of the properties of the constituent metals. For example, two metals of extreme hardness, when combined, might yield an alloy of only moderate hardness, rather than one as hard or harder than the individual component metals.

With few exceptions, metals used in dentistry are alloys. You should have an understanding of the structure and physical properties of the alloys used in dentistry so you are better qualified to: 1) determine the combination of physical properties required in an alloy to be used for a prosthesis; and 2) understand the proper manipulation and heat handling procedures which must be followed with the alloy selected in order to retain and make the most of its desirable properties.

Physical Properties of Metals. The physical properties of metals are described by definite, precise terms. A familiarity with the meaning of these terms is basic to an

understanding of the characteristic traits or the way a metal behaves under different conditions. Moreover, the suitability of a particular metal for a specific purpose can be determined only by someone who fully understands the terms used to describe its qualities.

- a. **Hardness.** This is a measure of the resistance of a metal to an indentation or scratch. It is an indication of the strength and wearability of the metal. Due to the varied functions the different types of dental prostheses must perform, hardness is a highly significant property of dental alloys.
- b. **Ductility.** Ductility is the property of a metal which permits it to be drawn into a thin wire without breaking.
- c. **Malleability.** Malleability is an indication of the amount of extension the metal can sustain in all directions without breaking. Malleability makes it possible to burnish the margin of a gold restoration to the tooth's surface and minimize the chance of leakage between the two. Gold is the most malleable of all metals. One grain of gold can be rolled and beaten into a leaf that is 6 square feet. A more brittle metal is less malleable.
- d. **Specific Gravity and Density.** Specific gravity is the weight of a unit of metal compared with an equal volume of water at the same temperature. Specific gravity is sometimes a factor in planning the design of a cast partial denture. The design selected for a dental prosthesis in which one of the heavier alloys is to be used might differ from one employing an alloy of a lighter weight.
- e. **Elasticity, Flexibility, and Resiliency.** Complete and technically accurate definitions of the terms elasticity, flexibility and resiliency are quite complex. For purposes in the laboratory, they refer to the characteristics of an alloy that enables it to bend under pressure and then return to its former shape when the pressure is removed. This is an important property in a removable partial denture clasp, as it must spring on and off an abutment tooth without exerting harmful pressure on the supporting structures of a tooth.
- f. **Elastic Limit, Proportional Limit, and Yield Strength.** These three terms have definitions that are subtly different. For practical purposes, terms are used interchangeably. A gross definition for all three would be: the maximum amount of stress than can be applied to a metal without permanently deforming the metal.
- g. **Percentage Elongation.** Elongation is a measure of the amount of alloy can be deformed without breaking. The percentage of elongation of an alloy has much to do with its suitability for making appliances which must

be bent or burnished into shape. The elongation should be as high as possible; consistent with strength requirements.

- h. **Grain Size.** When a metal is heated and allowed to cool, the rate of cooling affects the grain size. Slow cooling results in a comparatively large grain size. Fast cooling produces a finer grain structure. A metal with a fine grain structure is stronger than one which is coarse grained.
- i. **Grain Growth.** Prolonged heating below a metal's melting temperature may cause grain growth (small grains merge to form larger ones). This grain growth causes the metal to be brittle. Malleability and ductility can sometimes be restored in a metal which has become brittle by heat treating it. It is far better, however, to handle the metal in a way that it never becomes brittle.
- j. **Color of Heated Metals.** When gold alloys are heated, definite color changes occur. The temperature of the metal can be estimated by the color it radiates. As the metal is heated, these colors are observed in this sequence: dull red, brighter red, orange, and finally white as the temperature progressively increases. Temperatures associated with the colors are only approximations since color determinations differ from person-to-person. Another variable in appraising the color of a heated metal is the light under which it is examined. It may appear black in bright sunlight, but may look red when viewed in a shadow. When the color of a heated metal is evaluated, it should be viewed in as near normal light as possible.
- k. **Melting Range.** Pure metals melt suddenly at definite places or points on a temperature scale. Dental alloys do not melt abruptly at precise temperatures because they contain a number of metals with different melting points. When a high enough temperature is reached, an alloy first softens and becomes mush. As the heat is increased, the alloy gradually becomes more fluid until finally, it behaves much like a thick liquid. This gradual softening takes place over a spread of temperature known as the melting range. The lower limit of this range, known as the solidus, is the temperature at which the metal first begins to soften. The higher limit, called the liquidus, is the temperature at which the metal is wholly molten. The spread of the melting range for most dental gold casting alloys varies from 75 to 150 degrees F.
- l. **Fusion Temperature.** The manufacturer does not provide the melting range of a casting alloy. Very often the fusion temperature is provided instead. The fusion temperature is slightly above the lower limit of the melting range. It should never be exceeded when a metal is being soldered. The fusion temperature is provided to enable you to select a solder which has a melting range safely below the fusion temperature of

the parent metal. This minimizes the possibility of overheating the parent metal during a soldering operation.

Effect of Constituent Metals. The exact role of a metal varies with the particular alloy system to which the metal is added. For example, copper is included in many of the high palladium alloys to aid in forming an oxide layer for porcelain bonding. However, copper is added to the medium silver-palladium alloys to effectively lower their melting range and permit the use of gypsum-bonded investments. The following elements are frequently used in the traditional gold-base alloys.

Aluminum	Al	Added to lower the melting range of the alloy. It is also a hardening agent and influences oxide formation.
Beryllium	Be	Lowers the melting range, improves castability, serves as a hardener, and influences oxide formation. Reportedly, it improves polishability by acting as a lubricant for polishing agents, thus permitting them to work more effectively. Electrolytic “etching” of nickel-chromium-beryllium alloys removes a Ni-Be phase to create microretention for the etched-mesal resin-bonded retainers (Maryland Bridges).
Boron	B	A deoxidizer, a hardening agent, and an element which reduces the surface tension of an alloy, thereby improving castability. In the nickel chromium alloys, boron acts to reduce ductility and to increase hardness.
Chromium	Cr	Acts as a solid solution hardening agent, and ensures corrosion resistance by its passivating nature.
Cobalt	Co	Cobalt-base alloys are an alternate to the nickel-based types, but the cobalt-base metals are more difficult to cast.
Copper	Cu	Serves as a hardening and strengthening agent; lowers the melting range; and interacts with platinum, palladium, and silver (if present) to provide a heat-treating capability. It helps form oxides for porcelain bonding, lowers the density slightly and can also enhance passivity.
Gold	Au	Provides a high level of resistance to corrosion and tarnish (no associated passivity); and slightly increases the melting range, while it increases workability and burnishability. Gold imparts an esthetically pleasing color to the alloy, while it markedly increases density.
Indium	In	Serves as a less volatile scavenging agent; tends to lower the melting range (gold-base alloys); helps form an oxide layer for ceramic alloys; and lowers the density. Reportedly, an indium content of 20 percent can adversely affect the corrosion resistance of silver-base alloys.
Iridium and Ruthenium	Ir / Ru	These two elements serve as grain refiners to improve the mechanical properties and tarnish resistance.
Iron	Fe	Iron is usually added to gold-base ceramic alloys to harden the alloy and to aid in the production of oxides for porcelain

		bonding.
Manganese	Mn	Acts as an oxide scavenger, like silicon, to prevent the oxidation of other elements when the alloy is melted. It is also a hardening agent.
Molybdenum	Mo	Added to adjust the coefficient of thermal expansion, and to improve corrosion resistance. It also influences the oxides which are produced for porcelain bonding.
Nickel	Ni	Nickel has been selected as the base for alloys because its coefficient of thermal expansion is close to that of gold, and because it possesses a resistance to corrosion. It is easier to cast than the cobalt-base alloys.
Palladium	Pd	Added to increase the strength, hardness (with copper), corrosion, and tarnish resistance of an alloy. It increases the melting range and improves the sag-resistance of a ceramic alloy. Palladium has a strong whitening effect, which renders these metals as white alloys. It has a high affinity for hydrogen and it lowers the density of the alloy slightly.
Platinum	Pt	Increases the strength, melting range, and hardness while it improves the corrosion, tarnish, and sag-resistance of an alloy. It whitens the alloy and increases the density of the alloy.
Silicon	Si	Serves as an oxide scavenger to prevent the oxidation of other elements during the melt. It is also a hardening agent.
Silver	Ag	Silver imparts a moderate increase in the strength and hardness of an alloy (with copper); tends to tarnish in the presence of sulfur; possesses a rather high affinity for oxygen absorption, and lowers the density of the alloy. In ceramic alloys, silver lowers the melting range by counteracting the influence of palladium. High silver content ceramic alloys may produce discoloration (green or brown) in many porcelains.
Tin	Sn	Serves as a hardening agent; tends to decrease the melting range of the alloy; and helps produce an oxide layer in ceramic systems.
Titanium	Ti	Added to lower the melting range and improve castability. It also acts as a hardener and influences oxide formation.
Zinc	Zn	Helps lower the melting range, and acts as a deoxidizer or scavenger to combine with any oxides present. It improves the castability of an alloy and, when combined with palladium, contributes to its hardness. Zinc is commonly included in gold alloy solders.

CLASSIFICATION SYSTEM

The American Dental Association (ADA) previously classified alloys by function (Type I, II, III and IV); none of which was intended for metal-ceramic alloys. The ADA now classifies all alloys according to the percentage of noble metals present in the alloys. The

noble metals include gold and the six members of the platinum-palladium group- ruthenium (Ru), rhodium (Rh), palladium (Pd), osmium (Os), iridium (Ir), and platinum (Pt). The ADA classification system is as follows:

CLASSIFICATION	Au and Pt Group
High Noble	Greater than or equal to 90 percent
Medium Noble	Less than 90 percent; greater than or equal to 70 percent
Low Noble	Less than 70 percent
Base Metal	0 percent

DENTAL PORCELAINS

Highly glazed porcelain is one of the materials most compatible with oral tissues and one of the most esthetic of the dental materials. It is used for denture teeth, facings, making complete crowns, and veneering fixed prosthodontic units. Porcelain does not have the crushing or shear strength of cast metal, but when you use it in the proper bulk and with adequate support, it is very satisfactory for dental restorations.

Low-Fusing Dental Porcelain. All of the dental porcelains used to fabricate porcelain veneers or complete porcelain crowns fall into the low temperature range and are classified as low-fusing porcelain.

SEPARATING MATERIALS

In many laboratory procedures, two materials are brought together, but they must be prevented from sticking to each other. A separating medium is applied to the surface of one of the materials before the two are brought into contact.

Separating Gypsum Products from Each Other. When one gypsum product is poured on another, the materials tend to stick or unite. You may use these separators to prevent union of gypsum products.

- a. **Commercial separators.** Commercially available separators are obviously formulated to provide effective separation, but what is equally important, the film thicknesses they create are almost nonexistent. If these separators are not available, you should use liquid soap and floor wax.

- b. **Liquid Soap**. Ordinary soap is an effective separator and it is often used in flasking operations. You should brush it on evenly, and avoid foam or bubbles.
- c. **Liquid Floor Wax**. Ordinary liquid floor wax is an effective separator for both plaster and stone. You should apply it to a gypsum surface as a thin layer with a brush or a cotton pellet.
- d. **Petrolatum (Petroleum Jelly)**. The film left by petroleum jelly is too thick. Petroleum jelly must never be used where maximum accuracy is essential (for example, cast mounting procedures, index fabrication, etc.). Dentists and technicians dedicated to accuracy as a work standard contend that petrolatum has no place in the dental laboratory. In any event, petrolatum is sometimes used in denture flasking procedures. If you must use petrolatum as a separator, the material must be spread in the thinnest film possible.

Separating Gypsum Products from Acrylic Resins.

Both plaster and hydrocol are quite porous. They are not suitable surfaces against which to cure acrylic resins. A substance is needed to line the mold which seals off the pores. *Tinfoil* and *alginate* separating mediums are the best materials for this purpose.

Lubricant Separators.

When you wax a pattern on a die, you need a separator to prevent the wax from sticking to the die material. A lubricant must neither block out the fine details on the die nor affect the physical properties of the wax. The lubricants most frequently used are commercial preparations or substances like glycerol or mineral oil. If possible, you should use commercial separators to meet the high demands for accuracy in waxing and casting patterns.

Miscellaneous Separating Materials:

- a. **Talc (Talcum)** – a very fine, powdered soapstone. When it is sprinkled onto a cast and rubbed into its pores, it is a very effective separator against heated shellac baseplate material.
- b. **Plastic Sheets (Film)** – you should place plastic sheets between the halves of the flask so the resin does not stick to the bottom of the flask during trail packing.

Fluxes and Antifluxes.

Fluxes are substances which are applied to a metal to prevent the formation of an oxide film or to remove an already formed oxide film. Borax (sodium tetraborate) combined

with charcoal and silica is the principal constituent of most borax fluxes. Fluorides dissolve chromium oxide and are excellent fluxes for soldering base metal alloys. Fluxes are used in the dental laboratory in three different forms: 1) paste, 2) powder, and 3) liquid.

Alcohols.

Alcohol is used in the dental laboratory as a solvent and as a fuel for the alcohol lamp and the hand torch. There are several types of alcohol; some are suitable for laboratory use and some are not. A knowledge of the physical characteristics of the more commonly used alcohols is useful to you.

- a. **Grain Alcohol (Ethyl Alcohol, Ethanol).** This is a colorless liquid with a highly distinctive odor. It burns with a bluish flame and is a very satisfactory fuel for an alcohol torch.
- b. **Wood Alcohol (Methyl Alcohol, Methanol).** This is a colorless liquid with a pleasant odor which is made either synthetically from carbon monoxide and hydrogen, or by the distillation of wood. It is highly poisonous and burns in an alcohol lamp with a reddish-yellow, flickering flame. When air is supplied from the bellow in the hand torch, the flame becomes slightly purple. The yellow flame has the advantage of being easy to see in ordinary daylight. Although the flame is not as hot as the one produced by ethyl alcohol, it is satisfactory as a fuel for either the torch or lamp.
- c. **Denatured Alcohol.** Denatured alcohol is a mixture of ethyl alcohol and certain poisonous materials added to prevent its use as a beverage. Methyl alcohol, acetone, benzene, and ether are some of the common denaturing agents. As a fuel in the alcohol torch, it may burn easily, poorly, or not at all; depending on the volume and type of denaturing agent used. Because of the uncertainty of its behavior, ethyl or methyl alcohol is a better fuel for the alcohol torch.
- d. **Isopropyl Alcohol.** Isopropyl alcohol resembles ethyl alcohol very closely. It burns in an alcohol torch with a slightly more yellow and a somewhat more vigorous flame than either ethyl or methyl alcohol. Under pressure from the bellows of the hand torch, it produces a blue flame; however, it tends to smoke badly when applied to wax. For this reason, it is not recommended for most laboratory or clinical uses.

Acids and Pickling Agents

The acids are of interest to the laboratory technician because they are used in procedures to remove surface oxidation from the metal immediately after the castings have been recovered from the mold. When they are used for this purpose, they are called pickling

solutions. Acids must be handled with great care since they produce blisters and burns on the skin, ruin clothing and corrode equipment. Baking soda is the antidote for acid burns. It should be applied to the affected area immediately after contact. If an antidote is not available, you must flush the affected area with a lot of water. Generally, acids are not used full strength in the dental laboratory, but are diluted with water. When you make up a pickling solution, you must always pour the acid into the water – never the water into the acid. Failure to observe this rule may result in severe burns. All pickling solutions, except hydrofluoric acid, should be kept in glass containers with glass stoppers, and should be clearly labeled. One acid must never be mixed with another.

Types of Acid:

- a. **Hydrochloric Acid (U.S.P.)** – a colorless, very corrosive acid. The fumes attack and corrode equipment, instruments, and fixtures. As a pickling solution, it should be diluted with an equal part of water. On rare occasions, it may be used full-strength to remove sulphur deposits caused by an overheated mold. Hydrochloric acid slowly dissolves both platinum and palladium. For this reason, gold alloys should never be allowed to remain for more than a few minutes in acid. U.S.P. hydrochloric acid is 37 percent strength by weight.
- b. **Muriatic Acid** – another name for commercial hydrochloric acid. It may often contain impurities and may be slightly yellow. Like the U.S.P. grade, it is supplied in a 37 percent solution by weight. It makes a very satisfactory pickling solution when it is diluted to half strength with water.
- c. **Sulfuric Acid** – is a dense, oily liquid. It is an excellent pickling solution for gold in a solution of one part water to one part acid. It has an advantage over hydrochloric acid in that it produces no objectional fumes. It is a more effective pickling agent when it is warm.
- d. **Nitric Acid** – a colorless liquid which may turn brown if it is stored for a long period of time. The discoloration does not change the properties of the acid. It is seldom used in the laboratory because it dissolves gold alloys of high palladium content. Nitric acid is sometimes used to pickle a casting that is contaminated with copper deposits from an unclean pickling solution, when it cannot be cleaned with either hydrochloric or sulfuric acid. The solution used for this purpose is one part nitric acid to two parts water. Gold must never be left in nitric acid for more than a few minutes.
- e. **Phosphorous Acid** – rapidly dissolves dental cement and is very useful for removing facings or tube teeth from metal. It does not attack any of the commonly used dental alloys.
- f. **Hydrofluoric Acid** – should not be used except for dissolving porcelain veneers off metals. The fumes are dangerous if inhaled, and it is difficult

to neutralize when it comes in contact with the skin. Magnesium oxide ointment should be kept close by for burns if the acid is used. There are commercial hydrofluoric acid substitutes on the market that are much less hazardous.

- g. **Aqua Regia** – is a concentrated solution made of three parts hydrochloric acid to one part nitric acid. Aqua regia dissolves both gold and platinum. It is infrequently used to etch the inner surface of a gold inlay or crown to control the fit of the casting.

Wetting Agents

When water balls up on a wax surface, it is exhibiting a property called surface tension. If a wax pattern is invested, the surface tension of the water in the investment must be broken down in some manner; otherwise, the casting will very likely have nodules on its surface because the investment has failed to adhere closely to the wax. A wetting agent (debubbler) is a liquid with a soapy feel used to lower the investment's surface tension. When a wax pattern is properly prepared with a wetting agent, the investment flows evenly across the surface and into the small crevices of the wax. The resultant casting is free from nodules. In a similar manner, a wetting agent added to the water to flush out a denture mold lowers the surface tension of the solution and enables it to clean the mold more effectively.

Types of Wetting Agents

- a. Commercial Brand Name Preparations
- b. Hydrogen Peroxide and Green Soap
- c. Tergitol No. 7
- d. Household Detergent

Wax Solvents

Even though a substance may be able to dissolve wax, it may not be used for that purpose in dental laboratory technology. Wax dissolving substances:

- a. Acetone
- b. Carbon Tetrachloride
- c. Chloroform
- d. Xylene
- e. Commercial Wax Solvents

Abrasives and Polishing Agents

Abrasives are substances which wear away the surfaces of softer objects. The speed of their action depends on the relative hardness of the two materials. Abrasives are made

into powders by crushing and sifting them to produce the desired particle size. In dentistry, they are used as powders, cemented to the surface of paper and cloth in the form of discs, and bonded with binders to form grinding stones of various shapes. Abrasive materials can be classified according to their hardness using a scale known as the Mohs scale. The Mohs scale is a comparative scale, it is a good indicator of the relative abrasive power of several materials used to smooth and polish in the dental laboratory.

Types of Abrasives:

- a. Chalk
- b. Rouge
- c. Cuttlefish
- d. Tripoli
- e. Pumice
- f. Quartz
- g. Garnet
- h. Emery
- i. Carborundum (silicon carbide)
- j. Diamond

Laboratory Gases

Several kinds of gases are used for heating and melting operations. Some, such as oxygen and acetylene, are stored in highly pressurized containers with safety caps over the outlets. When the containers are moved or handled, the caps must be securely attached. If the outlets are broken away from the tanks, the high pressures propel the tank like a high-speed missile. The tanks must be secured to prevent their movement while they are in use.

Types of Gases:

- a. Natural Gas (City Gas)
- b. Acetylene
- c. Propane
- d. Oxygen

MISCELLANEOUS LABORATORY MATERIALS

Articulating Paper or Articulating Film. Articulating paper and articulating film are impregnated with a colored dye that is easily transferred upon contact. Both are used for marking interocclusal contacts when adjusting the occlusion of a fixed or removable prosthesis.

Modeling Clay. Modeling clay is a pure kaolin (aluminum silicate) which has been mixed with glycerine to form a moldable dough. In the laboratory, modeling clay is used to block out large tissue undercuts before a master cast is duplicated. It is also used to hold casts in position when they are mounted in an articulator. Because it shapes and molds easily, modeling clay is suitable for many other uses.

Cast Spray. Cast spray is used for coating the refractory cast to make a sealed surface against which to place wax or plastic patterns. Although the exact constituents are a trade secret, these sprays probably contain polystyrene plastic in solution.

Mouthguard Material. Custom mouth protectors (mouthguards) are made from polyvinyl acetate-ethylene blanks and preforms. This thermoplastic resin is molded over a cast using a vacuum-forming machine. Mouth protectors are worn during sports participation to reduce injuries to the oral tissues, head, and neck.

Plastic Patterns. Plastic patterns are plastic resin forms shaped as clasp arms, lingual bars, retention forms, etc. They are used to make up patterns for cast removable partial dentures. Since they are soft and pliable at room temperature, plastic patterns can be easily adapted to the designed outline on the refractory cast. They are made of ethyl and methyl methacrylate with added plasticizers. The exact composition of the plastics is a trade secret. They must be stored in a cool place to prevent deterioration.

Ring Liner (Formerly Asbestos Strip). Except under highly controlled conditions, the use of asbestos is being discontinued in many industries. Ceramic fiber paper is a commercially available substitute for conventional asbestos stripping. Since it is used to line the investment ring in fixed and removable partial denture investing procedures, the term ring liner is befitting. These asbestos substitutes are stiffer materials and generally nonabsorbent. Therefore, compared to asbestos, their use in the dental laboratory is limited to investing procedures only. Other materials are now used to replace asbestos for blocking out undercuts, lining crucibles, and insulating acrylic parts during soldering.

Shellac Resin. Shellac resin is used to make baseplates, although several other materials can be employed for this purpose. Shellac baseplates are marketed in the form of blanks which are manufactured from certain gum resins. They contain various waxes added as modifiers and plasticizers. Shellac resin is thermoplastic, it can be molded into a desired shape by applying heat.

Quick Setting Epoxy and Cyanoacrylate Adhesives. The strengths of these products are so high and the film thicknesses are so low that they are gaining increasing acceptance in dental laboratory technology. Epoxy and cyanoacrylate glues are used to reunite gypsum cast fragments. Epoxy glue contains enough body to be used as a block-out substance on fixed prosthesis dies. Painted on in a thin film, cyanoacrylate cement is an excellent die hardener and wax pattern spacer.

ANATOMY OF FACIAL AND ORAL STRUCTURES

The study of anatomy has a language all its own. The terms have evolved over many centuries. Most students think anatomical terms are hard to remember and pronounce, in some cases they are. In any event, you must learn and understand the terms that apply to the anatomical structures of dental interest and you must be familiar with oral and dental anatomy.

A. **General Reference Terms**

1. **Anterior and Posterior.** Anterior and posterior describe the front-to-back relationship of one part of the body to another. For example, the ear is posterior to (in back of) the eye, the nose is anterior (in front of) the ear, etc.
2. **Internal (Medial and External (Lateral)).** The words internal and medial are synonyms, so are external and lateral. These two terms describe the sideways relationship of one part of the body to another using the midsagittal plane as a reference. For examples, the ear is external (or lateral) to the eye because the ear is further from the midsagittal plane, the eye is internal (or medial) to the ear because it is closer to the midsagittal plane.
3. **Long Axis.** The longitudinal center line of the body or any of its parts.

B. **Body Planes.** The study of geometry shows that a plane is perfectly flat, is indefinitely long and wide, and has no depth. For our purposes, a plane is a real or imaginary slice made completely through a body. In anatomy, the slice is made to study the details of the cut surfaces. The cut surfaces are called sections or views. Planes can pass through a body in an infinite number of ways. There are common, standard planes that produce standard views:

1. **Sagittal Plane.** A plane that parallels the long axis and divides a body into right and left parts. A mid-sagittal plane divides bodies into equal right and left sides.
2. **Frontal Plane.** A plane that parallels the long axis and divides a body into anterior and posterior parts.
3. **Transverse (Horizontal) Plane.** A plane that divides a body into upper and lower parts. More specifically, it is a slice that passes through a body at right angles (90 degrees) to the sagittal and frontal planes.

C. **Bony Elevations:**

1. **Tubercle, Eminence, or Tuberosity.** All of these words describe rather small, somewhat circular areas that are raised above the general level of the surrounding bone. An elevation of bone that falls in this category was specifically labeled as an eminence, a tuberosity, or a tubercle by the person who originally described it. There might be little to distinguish among these kinds of elevations as far as relative shape and size are concerned. They just have to be memorized according to the names they carry.
2. **Ridge.** A linear elevation on the surface of a bone.
3. **Process.** A very prominent projection from the central mass of a bone.
4. **Condyle.** A rounded, convex, smooth surface on one of the bones that forms a movable joint.

D. Bone Depressions and Channels

1. **Fovea.** A shallow, cup-shaped depression or pit.
2. **Fossa.** A more or less longitudinal, rounded depression in the surface of a bone.
3. **Canal.** A tubular channel through bone. The channel has at least one entrance and one exit hole. A canal's entrance or exit hole is called a *foramen*.

E. **Joints.** Joints can be classified in a number of ways, one of the ways being the kind of movement that the structure of the joint allows. There are three kinds of joints found in the human skull.

1. **Synarthrosis or Immovable Joint.** Most bones of the skull are joined together along highly irregular, jigsaw puzzle-like lines called *sutures*. A suture joint is classified as a *synarthrosis*. Bones joined along suture lines in the skull are not totally immobile. Movement occurs, but it is very limited.
2. **Ginglymodiarthrodial Joint.** Literally defined, this is a freely movable, gliding, hinge joint. This relationship of one bone to another allows the greatest range of movement of any joint type. The term *ginglymodiarthrodial* specifically describes the *temporomandibular* joint that unites the lower jaw with the rest of the skull.
3. **Ellipsoidal Joint.** The type of joint that exists between the occipital bone of the skull and the first vertebra of the spinal column. There are two axes of motion at right angle to each other in this joint, and both axes pass

through the same bone. This arrangement enables you to nod your head and rotate it from side-to-side.

F. **Muscles**. The mass of a muscle is composed of many individual cells that are capable of contracting. The force generated by the muscle as a whole depends on how many cells in the muscle's mass are contracting at any given time. Muscles can pull (contract or shorten); they cannot push. A relaxed muscle cannot get any longer unless another contracting muscle somewhere else is forcing the extension. It should be obvious that a simple act like flexing and extending a finger requires at least two different muscles. The muscles used in flexing and extending a finger perform actions that are opposite one another. The performance of an action by one muscle that is opposed to the action of another is called *antagonism*. Besides having definite names, muscles are described in terms of:

1. **Origin**. A structure where a muscle attaches that moves the least when a muscle contracts.
2. **Insertion**. A structure where a muscle attaches that has the greater movement during contraction.
3. **Action**. The performance expected when a particular muscle contracts.

Bony Anatomy of the Head

The skull is that portion of the human skeleton which makes up the bony framework of the head. For descriptive purposes, the skull is divided into an upper, dome-shaped, cranial portion; and a lower or facial portion composed of the eye sockets, nasal cavities, and both jaws. The adult skull is composed of 22 bones (8 cranial and 14 facial).

Cranial and Facial Bones of Primary Interest in Prosthetic Dentistry.

Artificial replacements for missing natural teeth (dental prostheses) must be made to fit jaw contours and work in harmony with muscle activity. Facial bones of primary interest give shape to soft tissues within the mouth, serve as anchorage sites for muscles which move the lower jaw, and give shape to the lower one-half of the face.

A. Cranial Bones of Primary Interest

1. Frontal
2. Parietal
3. Temporal
4. Sphenoid

B. **Facial Bones of Primary Interest**

1. Maxilla
2. Palatine
3. Zygomatic
4. Mandible

INTRAORAL SOFT TISSUE ANATOMY

The muscles that form the sides, the entrance, and the floor of the oral cavity are the *buccinators*, the *orbicularis oris*, and *mylohyoids* (in that order). The skin of the interior of the mouth is called *oral mucous membrane* or *mucosa*. In places like the alveolar processes and the hard palate of the upper jaw, the mucous membrane is firmly and directly attached to bone. This kind of mucosa presents a stable surface. In other areas like the lips and the floor of the mouth, the mucous membrane covers active muscles that are constantly in motion, for example, the strong, muscular tongue is almost always moving. A removable prosthesis is built to use stable mucosa for support, and avoid areas of high muscle activity. There are soft tissue landmarks in the mouth that stay in the same places after natural teeth are extracted, these landmarks are valuable aids in prosthesis construction.

Mucous Membrane. Mucous membrane is the skin that lines the mouth.

- A. **Mucous Membrane of the Alveolar Process.** The mucous membrane of the alveolar process is divided into gingiva and alveolar mucosa.
1. **Gingiva.** Gingiva covers the crestal three-fourths of the alveolar process. There are two kinds of gingiva, free and attached. Free gingiva is about 0.5 mm wide and is found at the neck of a tooth. The attached gingiva is continuous with the free gingiva and is tightly bound to bone. The attached gingival band varies between 2 and 9 mm wide, the widest part is found in the anterior regions.
 2. **Alveolar Mucosa.** Covers the basal one-fourth of the alveolar process. Alveolar mucosa is very mobile because it is loosely bound to underlying bone.
- B. **Mucous Membrane of the Hard Palate.** The mucous membrane of the hard palate consists of attached gingiva.

Vestibule. The vestibules consist of two potential spaces. One vestibule is found between the facial aspect of the teeth and the internal surfaces of the cheeks and lips, and the other vestibule is found between the lingual aspect of the mandibular teeth and the tongue.

UPPER JAW

- A. **Alveolar Process.** The alveolar process is a process of the maxilla that surrounds the roots of natural teeth. The right and left alveolar processes combine to form the maxillary arch.
- B. **Alveolar Ridge (Residual Ridge).** The residual ridge is the remnant of the alveolar process which originally contained sockets for natural teeth. After natural teeth are extracted, the alveolar ridge can be expected to get smaller (resorb). The rate of resorption varies considerably from person to person.
- C. **Maxillary Tuberosity.** The maxillary tuberosity is the most distal (posterior) portion of the maxillary alveolar ridge.
- D. **Hamular Notch.** The hamular notch is a deep depression located posterior to the maxillary tuberosity. The depths of this depression is part of a series of guides used to determine the posterior border of a maxillary denture.
- E. **Palate.** The palate extends from the root of the mouth all the way back to the uvula.
 - 1. **Hard Palate.** The hard palate is made up of the anterior two-thirds of the palatal vault supported by bone (palatine processes of the maxillae and the horizontal plates of the palatine bones).
 - 2. **Soft Palate.** The soft palate is made up of the posterior one-third of the palatal vault that is not supported by bone. The soft palate is a muscular extension from the posterior edge of the hard palate, and the soft palate is very mobile, especially while speaking and swallowing.
- F. **Incisive Papilla.** The incisive foramen is located in the midline of the hard palate, immediately behind the central incisor teeth. The foramen is an exit hole for blood vessels and nerves. There is a definite bump or prominence in the oral mucosa which covers this hole in bone. The soft tissue bump immediately over the incisive foramen is called the incisive papilla. Since the incisive papilla is visible in the exact midline of the hard palate, just behind the natural central incisors, the papilla is a reliable guide for determining the midline relationships of upper anterior denture teeth.
- G. **Rugae.** Rugae are irregular ridges of fibrous tissue found in the anterior one-third of the hard palate.
- H. **Median Palatine Raphe.** The medial palatine raphe is a slight tissue elevation which occurs in the midline of the hard palate, immediately over the median palatine suture.

- I. **Vibrating Line.** When a dentist looks at a patient's entire palatal vault, it is easy to see an abrupt transition between the unmoving hard palate and the highly mobile soft palate. The vibrating line is the line of flexion between the hard and soft palates. The line most frequently falls between the two hamular notches, on or near the palatine foveae in the midline.
- J. **Palatine Fovea.** There are two palatine foveae. The two fovea are located on either side of the midline on, or very near the vibrating line. The palatine foveae are depressions made by two groupings of minor palatine salivary glands. NOTE: The vibrating line is the dentist's guide to determining the posterior border of an upper denture. In the absence of specific instructions from a dentist, the hamular notches and the palatine foveae are your guide for determining the posterior border of an upper denture.
- K. **Labial Frenum.** The labial frenum is a narrow fold of oral mucosa, which is found in the approximate midline. It extends from the inner surface of the lip to the labial surface of the alveolar ridge. The labial frenum is *not* a reliable guide for determining the midline of the face when natural teeth are absent.
- L. **Buccal Frenum.** There are two buccal frena. These frena are located on each side of the arch, usually in the first bicuspid region. Each frenum extends from the mucosa of the cheek to the buccal aspect of the alveolar ridge.
- M. **Sulci.** The maxillary sulcus is a groove formed by the mucosa of the cheek or lip and the mucosa at the base of the alveolar ridge. The portion of the sulcus which lies between the labial and buccal frena is called the *labial sulcus*, and the part of the sulcus between the buccal frenum and the hamular notch is the *buccal sulcus*. The muscles shaping the sulcus cause its depth to change with every facial expression a person makes.

LOWER JAW

- A. **Alveolar Process.** The alveolar process is the process of the mandible that surrounds the roots of the natural teeth. The right and left alveolar processes combine to form the *mandibular arch*. After natural teeth are extracted, the remnant of the alveolar process is called the *alveolar* or *residual* ridge. As time goes on, a residual ridge usually resorbs (gets smaller).
- B. **Retromolar Pad.** A pear-shaped mass of soft tissue located at the posterior end of the mandibular alveolar ridge. The retromolar pads are important for these reasons:
 - 1. When maxillary and mandibular natural teeth are brought together, a plane of contact automatically forms between the occlusal surfaces of the upper and lower teeth (occlusal plane). When this plane of contact is projected

posteriorly, it intersects with the mandible at two points; one point is on each side of the arch. These points are about two-thirds of the way up the height of the retromolar pads. The position of the pads remains constant, even after the natural teeth are extracted. These facts ensure that *the pads are an excellent guide for determining and setting the plane of occlusion between upper and lower denture teeth.*

2. The pads serve as bilateral, distal support for a mandibular denture. *Covering the pads with the denture base helps reduce the rate of alveolar ridge resorption.*
- C. **Buccal Shelf.** The buccal shelf is a ledge located buccal to the base of the alveolar ridge in the bicuspid and molar regions. Laterally, the shelf extends from the alveolar ridge to the external oblique line. A buccal shelf is barely observable when the alveolar ridge is large (the shelf increases in size as the ridge resorbs). *The buccal shelf is a support area for a mandibular denture, especially when the remaining alveolar ridge is relatively small.*
- D. **Mental Foramen.** The mental foramen is a hole in bone ordinarily found on the buccal surface of the alveolar ridge. It is located between and slightly below the root tips of the first and second bicuspid teeth. There is no tissue bump over the hole as in the case of the incisive foramen. When resorption of the alveolar ridge is drastic, the mental foramen is found below the oral mucosa on the crest of the alveolar process. In these cases, relief of the denture is necessary to avoid excessive pressure on the nerve fibers which exit from this foramen, compression results in loss of feeling in the lower lip. *Relief* in this case is defined as space provided between the undersurface of the denture and the soft tissue to reduce or eliminate pressure on certain anatomical structures.
- E. **Frena.** The labial and buccal frena of the mandible are in corresponding positions to their counterparts in the upper jaw. Also, a lingual frenum can be seen in the floor of the mouth when the tongue is raised. The lingual frenum is present in the approximate midline and extends from the floor of the mouth to the lingual surface of the alveolar ridge.
- F. **Sulci.** Sulci rise and fall with facial expressions and tongue movements.
1. **Labial Sulcus.** The labial sulcus of the lower jaw lies at the base of the alveolar ridge between labial and buccal frena.
 2. **Buccal Sulcus.** The buccal sulcus extends posteriorly from the buccal frenum to the buccal aspect of the retromolar pad.
 3. **Lingual Sulcus.** The lingual sulcus is the groove formed by the floor of the mouth as it turns up onto the lingual aspect of the alveolar ridge.

- G. **Floor of the Mouth.** The anterior two-thirds of the floor of the mouth is formed by the union of the right and left mylohyoid muscles in the midline. The depth of the floor of the mouth in relation to the mandibular alveolar ridge constantly changes due to factors such as mylohyoid muscle contractions, tongue movements, and swallowing activities. The posterior one-third of the lingual sulcus area is called the *retromylohyoid space*, distally, the area is shaped by the *palatoglossus* muscle.

THE TONGUE

The tongue is a muscular organ that contains specialized cells for detecting the presence of chemicals in the food we eat. The brain interprets this chemical detection process as taste. The tongue's many different sets of muscles enable it to make the complex movements associated with speaking and with chewing food. The constant motion of the tongue represents a powerful force, and no artificial dental replacement can restrict that motion for long. If a prosthesis is not constructed to work in harmony with the tongue, it will fail. For example, the tongue can maintain a denture in position or throw it out, depending on how the lingual surfaces and borders of the denture are shaped. The tongue is animated by two muscle groups, the intrinsic and extrinsic.

THE TEMPOROMANDIBULAR JOINT

The right and left temporomandibular joints are the two places where the mandible connects with the rest of the skull. In general terms, the temporomandibular joint is formed by the glenoid fossa and articular eminence of the temporal bone and by the condyle of the mandible. The fossa and eminence are separated from contact with the condyle by an articular disc.

DENTAL TOOTH ANATOMY

Groups of Teeth. Teeth, as they exist in the mouth, can be placed into any of three broad groupings, the maxillary or mandibular, right or left, anteriors or posteriors. These groupings apply to both the natural dentition and to artificial teeth.

- A. **Maxillary or Mandibular.** A person has two jaws, a maxillary (upper) and a mandibular (lower). The teeth in these jaws are called either maxillary or mandibular teeth. The combination of natural teeth and supporting alveolar bones that is found in an upper or a lower jaw is called a dental arch. When natural teeth are extracted, the healed alveolar process is called the residual ridge. You are expected to set artificial teeth over residual ridges so they coincide with the original arch form.
- B. **Right or Left.** If we split the two dental arches down the midline from front to back, the arches can be divided into upper and lower right sections and upper and lower left sections. Since one of these sections represents one-fourth of the upper and lower arches taken together, the section is called a quadrant. If a tooth is located to the left of the midline in the upper arch, the tooth is part of the maxillary left quadrant (etc.).
- C. **Anteriors or Posteriors.** Teeth can also be classified as anteriors (incisors and cuspids) or posteriors (bicuspid and molars). A complete adult natural dentition has 32 teeth; each arch contains 16. The teeth in an arch are composed of 6 anteriors (cuspid to cuspid) and 10 posteriors (all teeth distal to the cuspids). There are 3 anteriors and 5 posteriors in a quadrant. NOTE: Complete dentures for the upper and lower arches usually consist of 28 teeth. The 4 third molars are not used.

Structure of the Teeth and Surrounding Tissues

- A. **Teeth.** A tooth is divided into two parts, the *crown* and the *root*. The *anatomical crown* is the part of the tooth covered with enamel. The root of a tooth is embedded in alveolar bone and covered with cementum. The term *clinical crown* is applied to the part of the tooth that is visible above the gingiva to include root surface. The bulk of a tooth is composed of a bone-like substance called *dentin* which is covered by enamel to form the crown and *cementum* to form the root. The line of division between the crown and root is called the *cervical line* or *cementoenamel junction*. The dividing line is found in a somewhat constricted region on the tooth's surface called the *cervix* or *neck*. The tip of the root is known as the apex. The tooth contains an aggregate of blood vessels, nerves, and cellular connective tissue called the *dental pulp*. The dental pulp is housed within a pulp chamber and root canal of a tooth. Anterior teeth ordinarily have one root canal; multiple canals occur in posterior teeth. The nerves and blood vessels enter and leave the tooth through an opening called the *apical foramen* at or near the apex of the root.

B. **Supporting Structures of the Teeth.** The supporting tissues of the teeth are collectively called the periodontium. The periodontium consists of the alveolar process of the maxillae and the mandible, the periodontal ligament, the cementum of the tooth, and the gingiva.

1. **Alveolar Process.** The alveolar process is the portion of the maxillae or mandible in which the roots of the teeth are embedded and by which tooth roots are supported. An alveolar process consists of three kinds of bone. They are the outer cortical plate, lamina dura, and spongy bone. The outer cortical plate is a compact layer of bone on the bone's surface. The lamina dura is a thin, dense layer of bone that lines tooth sockets. The lamina dura is a specialized continuation of the cortical plate. Spongy bone is the less dense cancellous bone representing the alveolar process' central mass.
2. **Periodontal Ligament.** The periodontal ligament is a thin, fibrous ligament connecting a tooth to the lamina dura of the bony socket. Normally, teeth do not contact the bone directly; a tooth is suspended in its socket by the fibers of the ligament. This arrangement allows each tooth limited individual movement. The fibers act as shock absorbers to cushion the force of chewing impacts.
3. **Cementum.** The cementum is the only tissue considered as both a basic part of the tooth and a component of the periodontium. It is a thick, calcified layer of tissue that completely covers the dentin of a tooth's root. Cementum is formed during the development of the root. It functions as an area of attachment for periodontal ligament fibers.
4. **Gingiva.** The gingiva is the specialized mucous membrane covering the alveolar processes and encircling the necks of the teeth. It aids in the support of the teeth, and protects the alveolar process and periodontal ligament from bacterial invasion. Healthy gingiva is pale pink, firm and resilient. It is divided into two types, free and attached gingiva.
 - a. **Free gingiva** is "free" to the extent that it can be displaced; it is not tightly bound to anything underneath it. Free gingiva extends from the gingival crest to the bottom of the gingival sulcus. At the bottom of the sulcus, an epithelial attachment joins the free gingiva to the tooth surface. The interdental papilla is the portion of the free gingiva that fills the proximal space below the contact areas of adjacent teeth. It helps prevent food from packing between the teeth.
 - b. **Attached gingiva** covers the labial cortical plate of the alveolar process. It is firmly fixed to underlying bone.

OCCLUSION

Occlusion is defined as “any contact between opposing cutting or chewing surfaces of maxillary and mandibular teeth.” Many patterns of tooth contact are possible. Part of the reason for the variety is the mandible’s condyle’s substantial range-of-movement within the temporomandibular joint.

Restorative occlusion studies usually center around tooth-to-tooth relationships in these five classical mandibular positions:

1. Maximum contact between upper and lower teeth.
2. Lateral movement contact relationships.
3. Protrusion.
4. Retrusion.
5. Centric relation.

Centric Occlusion. *Centric occlusion* is the centered contact position of the chewing surfaces of mandibular teeth on the chewing (occlusal) surfaces of the maxillary teeth.

- A. **Occlusal Plane.** Maxillary and mandibular teeth come together in centric occlusion and meet along anteroposterior and lateral curves. The composite of these curves is a spherical surface. The *occlusal plane* is the mean curvature of an imaginary spherical surface that touches the incisal edges of the anterior teeth and the cusp tips of posterior teeth.
- B. **Vertical and Horizontal Overlap.** *Vertical overlap* is the extension of the maxillary teeth over mandibular counterparts in a vertical direction when the dentition is in centric occlusion. *Horizontal overlap* is the projection of maxillary teeth over mandibular antagonists in a horizontal direction.
- C. **Angles’s Classification.** Angle was a dentist who developed a classification of the normal and abnormal ways people bring their teeth into centric occlusion. Angle came up with three classes, Class I, Class II, and Class III. The classes are based on a person’s profile, the position of the mesiobuccal cusp of the upper first molar relative to the buccal developmental groove of the lower first molar, and the upper anterior to lower anterior tooth relations in terms of vertical and horizontal overlap.

CLASS I

- a. The patient’s profile is characterized as normal.
- b. The mesiobuccal cusp of the upper first molar falls in the buccal groove of the lower first molar when the teeth are in centric occlusion.

- c. In the anterior area, there is a normal range of horizontal overlap (0 to 2 mm); also, there is a normal range of vertical overlap (1 to 5 mm).

CLASS II

- a. The patient's profile is deficient in chin length and characterized as a retruded (retrognathic) profile.
- b. The mesiobuccal cusp of the upper first molar falls anterior to the buccal groove of the lower first molar in centric occlusion.
- c. In the anterior area, horizontal overlaps in excess of 10 mm are not uncommon. Vertical overlaps where the lower incisors make indentations in the skin of the palate happen occasionally. In any event, the most significant feature about the anterior tooth relationships in Angle's Class II is the marked horizontal overlap.

There are two subdivisions of Angle's Class II:

- 1) **Class II, Division I (II/1)**. In Class II/1 malocclusions, the maxillary incisors have a normal labiolingual inclination or are too much protruded.
- 2) **Class II, Division 2 (II/2)**. In Class II/2 malocclusions, two or more maxillary incisors are tipped palatally.

CLASS III

- a. The patient's profile is excessive in chin length and characterized as a protruded (prognathic) profile.
- b. The mesiobuccal cusp of the upper first molar falls posterior to the buccal groove of the lower first molar in centric occlusion.
- c. In the anterior area, the upper and lower anteriors are usually edge-to-edge (0 mm of vertical and horizontal overlap). Negative vertical and horizontal overlaps are possible (the lingual surfaces of the lower anteriors are forward to, and extend up, over the incisal edges of the upper anteriors.).

D. Cusp Position in Centric Occlusion

- 1. **Cusp Types**. From a functional point of view, there are two types of cusps:

- a. **Stamp Cusps (Lingual of the Upper and Buccal of the Lower).** Another name for a stamp cusp is vertical dimension of occlusion holding cusp. This is because stamp cusps act to maintain a constant distance between the upper and lower jaws when the teeth are in centric occlusion.
 - b. **Shearing Cusps (Buccal of the Upper and Lingual of the Lower).** By exclusion, shearing cusps are cusps other than stamp cusps. Shearing cusps do not maintain the vertical distance between the upper and lower jaws when the teeth are in centric occlusion.
2. **Cusp Relationships with Opposing Teeth.** When teeth come into centric occlusion (Class I, II or III), the stamp cusps in one arch hit in fossae or across occlusal embrasures of the teeth in the opposite arch. Two basic varieties of stamp cusp arrangement are used in making prosthodontic restorations:
- a. **The Cusp to Occlusal Embrasure Pattern.** Variations of this pattern are frequently seen in natural dentition. This is the type of cusp placement that was originally established for complete denture setups. It is basically a one-tooth-to-two-teeth relationship of all of the teeth except the mandibular central incisor and the last maxillary molar. In centric occlusion, most of the mandibular buccal cusps are in embrasure contact with the maxillary teeth, and almost all of the maxillary lingual cusps are in a fossa relationship with the mandibular teeth.
 - b. **Cusp to Fossa Pattern.** This type of cusp placement locates all mandibular buccal cusps into the fossae of their maxillary counterparts. Also all maxillary lingual cusps are positioned in the fossae of their mandibular antagonists. Under ideal conditions, it is a tooth-to-tooth relationship: each mandibular posterior tooth contacts one maxillary opponent. Although the cusp to fossa pattern is extensively used to restore teeth in fixed prosthetic dentistry, it is rarely seen in the natural dentition. A cusp to fossa relationship has several advantages over a cusp to embrasure relationship. A cusp-fossa relationship better directs forces over the long axes of the teeth. It helps stabilize individual teeth in their respective positions in the dental arches. It also helps to prevent food impaction between teeth because there are no cusp tips striking in the embrasures to force the teeth apart.
 - c. **Crossbite.** In normally related cases, the buccal cusps of the lower teeth and the maxillary lingual cusps are the vertical dimension of

occlusion holding (stamp) cusps. In centric occlusion the buccal cusps of the maxillary posteriors horizontally overlap the buccal cusps of the mandibular teeth. Also, horizontal overlaps in the anterior area are the rule. A crossbite exists when either or both of these tooth relationships are present in centric occlusion:

1. If the stamp cusp and hearing cusp relationships found in normally related cases are reversed.
2. If the upper-to-lower anterior tooth relationships are reversed. The crossbite condition can occur between a single upper and the opposing lower tooth, a few upper and the opposing lower teeth, or throughout the dentition.

- d. **Value of Centric Occlusion in the Natural Dentition.** The centric occlusion position is a highly reproducible guide for restoring the shape of badly broken down natural teeth. It is also a guide for aligning and shaping artificial teeth for partially edentulous arches. A dentist checks the height of all kinds of restorations by asking the patient to bring opposing teeth into centric occlusion. A technician routinely makes restorations on casts that have been related to each other in centric occlusion. When a natural dentition has grossly deteriorated or when all teeth have been extracted, one of the best means a dentist had for accurate, reproducible positioning of the lower jaw in relation to the upper is gone. Restorative challenges like making complete dentures or rehabilitating an entire natural dentition require a dentist to make an educated guess. He or she needs to determine just where the lower jaw was located when the natural teeth contacted in correct centric occlusion. The problem is two-fold: properly orientating the lower jaw vertically, and properly positioning the lower jaw horizontally.

Vertical Dimension. Vertical dimension is any measurement of vertical distance between the upper and lower jaw. A mandible can travel and stop anywhere on a path between maximum opening and closure. If a vertical measurement is to have meaning, it should identify a place along the potential path of travel that the dentist and the patient can find on demand.

Centric Relation. Centric relation is defined as the rearmost, uppermost, midmost (RUM) unstrained position that the condyles can occupy in the glenoid fossae at a given vertical dimension. The condyles of most people whose natural teeth are in centric occlusion are situated 1.25 mm plus or minus 1 mm, forward of centric relation. When surfaces of teeth are grossly deteriorated or when all teeth are lost, there is no way of telling exactly where the normal centric occlusion position places the condyles in the glenoid fossae (for example, in centric relation? 1.14 mm forward of centric relation?)

.368 mm forward of centric relation?). In these cases, dentists use the highly reproducible centric relation position to horizontally orient the lower jaw for prosthesis construction procedures. How do we rationalize the probability that the condyles were not in centric relation when the patient had a full complement of sound natural teeth in good centric occlusion? Fortunately for dentistry, most patients function well when the centric relation position is used to horizontally orient the lower jaw to the upper. As an example, denture teeth are purposely assembled to come together in centric occlusion when the condyles are in centric relation.

Mandibular Movements. The mandible is capable of many different, subtle kinds of movements. When the mandible moves, the condyles most certainly move with it, but the type and direction of condylar movement are not necessarily the same in each joint. The basic mandibular movements consist of hinge, translatory, and lateral motions. Most of the time a typical mandibular movement is a smooth, fluid blend of two or three of the basic motions. The basic movements have these major subdivisions:

- a. Hinge Movements
- b. Protrusion or Retrusion
- c. Right and Left Lateral Movements
- d. Occlusal Disharmony

ARTICULATORS

Articulators and Their Function. An articulator is a mechanical device in which the patient's maxillary and mandibular casts are mounted. Most articulators are supposed to simulate positions and movements of the patient's lower jaw in relation to the upper jaw so a prosthesis with a proper occlusion can be made. The accuracy of the simulation depends on the accuracy of the dentist's transfer records and the degree of adjustability of the instrument. The following records are important:

- a. The vertical and horizontal orientation of the upper jaw to both temporomandibular joints.
- b. The patient's actual centric occlusion, or the dentist's estimate of where centric occlusion should occur.
- c. The angles that the articulator eminences form with the occlusal plane.
- d. The temporomandibular joint characteristics that govern the timing and direction of the Bennett movement (sideshift).
- e. The distance between the patient's condyles (intercondylar distance).
- f. Relative presence or absence of anterior guidance.

Types of Articulators. There are many different kinds of articulators available. The primary difference among them is in the number of controls or adjustments they possess. Articulators that have a full range of adjustments can be set to match the patient's guiding anatomical features. As a result, articulator movements come very close to duplicating the patient's actual jaw movements. Articulators with no adjustments are built to move in a statistically average manner, cannot be set to move in any other way, and have much more limited application. Based on the adjustability factor, articulators fall into three broad categories: nonadjustable, semiadjustable, and fully adjustable.

a. **Nonadjustable Articulators:**

1. **Hinge Type.** This variety is the simplest made. It can make a basic opening and closing movement. It has no ability to go into lateral or protrusive excursions. Sometimes these devices are called "holding" instruments. Their only function is to hold or maintain the vertical and horizontal relationships between two casts at one mandibular position. Most of the time, hinge instruments are used to make very simple fixed and removable prostheses (that is, artificial replacements where the dentist fully expects to correct lateral and protrusive interferences in the mouth at the time the prosthesis is inserted). Examples of these replacements would be a temporary fixed partial denture or an

interim removal partial denture. It is possible to make very complicated, “permanent” restorations with a pure hinge instrument. For a hinge instrument to be used this way, the dentist would have to use functionally generated chewing surface techniques to get adequate cast mountings for the job.

2. **Fixed-Guide Articulators.** Fixed-guide articulators are machined to produce the lateral and protrusive movements that are characteristic of a statistically average patient. If the “average” movements of the articulator match the actual movements of the patient, the patient is in luck. These kinds of articulators are used extensively and the success rate associated with their use appears to be acceptable. The ability of these articulators to hold vertical and horizontal relationships between opposing casts is their most dependable performance feature. Lateral and protrusive movement paths are only moderately dependable. Functionally generated chewing surface techniques aside, fixed guide articulators should be used for cases where precise duplication of lateral movements is not critical. Examples of these cases are complete crowns for incisor teeth; short span anterior fixed partial dentures; posterior onlays; crowns, and short span fixed partial dentures where anterior guidance is immediate and steep; monoplane complete dentures using 0 degree teeth; or removable partial denture construction for a patient with a definite anterior-guided occlusion.

b. **Semiadjustable Articulators.** A semiadjustable articulator is one having enough adjustable features to give a fair simulation of a patient’s actual mandibular movements. Many articulators in this class can compensate for the angle of a person’s articular eminence, horizontal and vertical overlap conditions, and the amount of progressive sideshift. Some have fewer adjustments (no variable progressive sideshift), and some have more adjustments (immediate sideshift, progressive sideshift, and variable intercondylar distance). Semiadjustable articulators are very versatile. They are used for making all forms of removable prostheses and for moderately complicated fixed prosthodontic replacements. Some dentists use the most adjustable of the articulators in this group of complete mouth fixed prosthodontic rehabilitations. Two brands, the Hanau H2 and the Whip-Mix, are in common use by the US Air Force Dental Service. There are two ways of using semiadjustable articulators from the standpoint of making them match the patient’s anatomical features and resultant mandibular movement:

1. **Arbitrary or Average Mode.** Only those patient factors that are most critical to the success of the case are reproduced on the articulator with the greatest accuracy possible (for example, centric relation, and centric occlusion, vertical dimension of occlusion.)

Statistical averages are used to set all remaining articulator adjustments. The so-called “average” settings are supposed to hold true for the majority of the patient population. When a semiadjustable articulator is used in this way, it becomes a fixed guide instrument and has the same limitations.

2. **Semiadjustable Mode.** The dentist mounts the patient’s casts and sets all articulator adjustments based on actual patient measurements. Two kinds of measurement systems are used:
 - (a) **Facebow Transfer.** A facebow transfer is a procedure used to mount a maxillary cast in an articulator in the same way the maxillae relates to the temporomandibular joints. When the infraorbital canal is used as a third point of reference in a facebow transfer, the maxillary cast is also related to the horizontal plane of the articulator as the patient’s maxillae relates to the axis-orbital plane.
 - (b) **Jaw Relationship Records.** The articulator’s adjustments are set according to three dimensional methods of measurement called jaw relationship records. There are two types of jaw relationship records. The first is a template that permits articulator mounting of the lower cast against the upper cast in the same way the jaws relate when the record is made in the patient’s mouth (for example, centric relation record). After the casts are mounted, the second kind of jaw relationship record is used to set articulator adjustments (lateral and protrusive records).
- c. **Fully Adjustable.** This category differs from the semiadjustable group due to features like custom ground condyle guides, fully variable intercondylar distance, very close simulation of the timing and direction of Bennett movement, and a capacity to simulate the direction of the rotating condyle. The information needed to accomplish these highly refined adjustments does not come from jaw relationship records. It comes from mandibular movement tracings (pantographic tracings) made by the patient under the direction of the dentist. The articulator is then programmed to conform to the tracings. Fully adjustable articulators are meant to be used on the most demanding kinds of cases (detecting and treating patients whose jaw movement patterns are not normal and in complete mouth fixed prosthodontic restorations). A fully adjustable

instrument can be used in the fixed-guide and semiadjustable modes if a less adjustable articulator is not available.

Parts of the Hanau H2-158 Articulator

- a. Upper Member
- b. Lower Member
- c. Mounting Planes
- d. Condylar Shaft
- e. Post
- f. Horizontal Condylar Guidance and Lockscrew
- g. Horizontal Condylar Indication
- h. Condylar Element
- i. Centric Stop
- j. Centric Lock
- k. Lateral Condylar Guidance and Lateral Condylar Indication Scale
- l. Incisal Guide Pin and Lockscrew
- m. Incisal Guide Table and Lockscrew

Parts of the Whip-Mix Articulator

- a. Upper Frame
- b. Lower Frame
- c. Mounting Plates
- d. Upright
- e. Condyle Element
- f. Condylar Guide and Horizontal Condylar Indication Scale
- g. Condylar Guide Clamp and Locking Screw
- h. Intercondylar Distance Spacers
- i. Sideshift Guide and Lateral Condylar Indication Scale
- j. Incisal Guide Pin and Locking Screw
- k. Incisal Guide Table and Locking Screw
- l. Detent
- m. Facebow Mounting Pin

DENTAL LABORATORY EQUIPMENT IDENTIFICATION

1. **Articulator, Hanau H2-158.** An articulator is a mechanical device, which represents the temporomandibular joints and the jaw members, to which maxillary and mandibular casts are attached. It is used to set artificial teeth in prosthetic appliance fabrication.
2. **Autoduplicator, Ticonium.** The Autoduplicator conditions laboratory hydrocolloid by chopping it into small pieces and liquefying it by a high heat breakdown. After breakdown, the unit automatically cools the prepared colloid to a holding (storage) temperature of 125 to 128 degrees F.
3. **Bath, Hygroscopic Water.** The water bath is used in conjunction with the hygroscopic investing technique for crown and fixed partial denture fabrication. If properly calibrated, it raises room temperature water to 100 degrees F and maintains the water at that temperature. Immersion of an invested mold in this bath allows uniform expansion of the invested wax pattern and ensures the 100 percent humid atmosphere necessary for the hygroscopic component of investment expansion.
4. **Blaster, Shell or Sand.** The shellblaster and sandblaster have identical construction characteristics. They differ only in abrasive content and use.
 - a. The shellblaster uses crushed walnut shells as abrasives. It is used to remove gypsum products from an acrylic resin prosthesis during the deflasking operation. Walnut shells do not affect the teeth or denture base.
 - b. The sandblaster uses zircon grit as an abrasive. It is used in cast removable partial denture work to remove casting investment and surface oxides from the metal framework. The sandblaster must never be used on acrylic or porcelain because it will ruin them.
5. **Burner, Hanau Touch-O-Matic.** This burner is used in the laboratory for heating wax-carrying instruments and a variety of other procedures where an open flame heat source is required.
6. **Casting Machine, Unitek Autocast.** Casting machines are devices that fling molten metal into a mold. The Unitek Autocast® is an electronic induction type casting machine used to cast all kinds of dental alloys. In the Air Force, it is used primarily to cast metallic substructures, but it can also be used to cast full gold units or

removable partial denture frameworks. Induction casting machines use an electromagnet field which is set up around the metal. It melts the metal by rapidly rearranging the molecules of the metal.

7. **Casting Machine, Broken Arm.** This type casting machine requires an external heat source to melt the metal, usually a gas and air blowpipe. The casting machine is spring loaded and wound to operate.
8. **Casting Machine, Thermotrol® 2500 Electric.** This conduction type casting machine is used to electronically melt conventional and porcelain fused-to-metal gold alloys and cast them by centrifugal force into a heated mold.
9. **Casting Machine, Ticomatic Electric.** The Ticomatic casting machine is similar to, but larger than the Unitek Autocast. The Ticomatic is primarily designed to cast removable partial denture frameworks, but it can be modified for other applications.
10. **Chamber, Sandblasting, Portable.** Use this unit in conjunction with the Paasche® Airbrush or similar mini airbrush unit to prevent contamination of adjacent laboratory areas by abrasive and investment particles.
11. **Chisel, Pneumatic.** The air chisel is primarily used to break or fracture artificial stone, for example, divesting processed dentures, removing stone from the tongue space of mandibular casts, removing stone from the mounting rings, etc.
12. **Chuck, Wells® Quick Release.** When it is correctly installed on a bench lathe, the Wells Quick Chuck allows the operator to change chucks and burs while the lathe is in motion, which greatly decrease the time spent in the finishing and polishing procedures.
13. **Cleaning Unit, Ultrasonic.** This unit is filled with locally or commercially cleaning compounds. It uses ultrasonic vibrations to clean dental restorations, appliances, and small equipment items.
14. **Crucible.** Crucibles are containers in which various dental alloys are melted. They are designed to channel the liquefied alloy into a casting mold during the casting procedure. They must be capable of withstanding exceptionally high melting temperatures without deteriorating.
15. **Curing Unit, Hanau Model II®.** Curing or polymerization, of acrylic resins is a chemical reaction between the polymer and monomer. The heat generated by this reaction may cause an internal

temperature as high as 300 degrees F. When monomer boils, it results in a porous denture base. The objective in curing is to control the temperature generated by the polymerization so the monomer does not boil. A curing unit must contain:

- a. A positive means of controlling the rate of heating.
- b. A rack to prevent flask and heating coil contact.
- c. A volume of water that is sufficient to prevent too rapid a rise in temperature.

16. **Curing Unit, Ivomat®.** The Ivomat curing unit is used with the Isosit® system of making veneered crowns and fixed partial dentures. The Ivomat uses heated water and pressure to polymerize the Isosit material.
17. **Dowel Pin Drill, Pindex®, Accu-drill®, Accudex®.** The dowel pin drill is used to drill parallel dowel pin holes in the underside of an initial pour of a working cast. Specially designed deowel pins are then cemented in the holes and the cast base is completed. The dowel pin drill has a light beam or mechanical pointer used to position the drill bit directly under the tooth preparations.
18. **Electro-Polisher, Ticonium.** The Ti-Lectro® polishes cast removable partial denture metal frameworks using an electrolytic deplating process.
19. **Engine, Bench (Rabbit Ears).** Many technicians prefer a bench engine due to its versatility and mobility. It can be angled to reach awkward areas. The motor is equipped with a rheostat to vary the speed and a switch to reverse the direction of motor rotation. The dental engine is used to operate the straight handpiece.
20. **Etching Unit, Time Etch®.** The Time Etch unit is used to electrically deplate (etch) base-metal alloy casting for the resin-bonded fixed partial denture technique. The Time Etch unit has a magnetic stirring device in addition to the normal current controls and timer.
21. **Flask, Denture.** A denture flask is used to form the mold that processes the acrylic resin portion of the prosthesis. The flask is comprised of four sections or parts, the knock-out plate, bottom half (drag), top half (cope), and cap (or lid). Each flask has the same number on all of its parts, except the knock-out plate. It is imperative to keep the parts with the same numbers together, since they are machined to fit each other.

22. **Gauge, Metal Thickness.** This device is used to accurately measure the thickness of metal. The thickness is measured for these reasons:
- a. To avoid grinding a hole in an extremely thin restoration or appliance.
 - b. To eliminate bulk in an appliance or restoration.
 - c. To grind or contour to exact tolerances, when the thickness of the metal is critical.
23. **Gauge, Wax Thickness.** Use this instrument to accurately measure the thickness of dental waxes to ensure sufficient casting thickness or to avoid overwaxing (bulk) of various patterns.
24. **Handpiece, Laboratory Straight.** This is a hand-held, revolving spindle with a chuck in front to hold burs, stones, and mounted points.
25. **Handpiece, Electric.** This handpiece combines the functions of a bench engine and a handpiece, without the restrictions of pivoting metal arms, pulleys, and a drive belt.
26. **Heater, Beeswax.** This heater is designed to melt refined beeswax and maintain the wax at a holding temperature of between 280 degrees F and 300 degrees F. It is used primarily for wax dipping refractory casts in removable partial dentures.
27. **Heater, Dura Dip® Electronic Wax.** The Micro Dura Dip is used to melt specially prepared inlay wax for the wax dipping technique used to form coping patterns. The unit's electronic circuitry and sensor allow precision adjustment of the molten wax's temperature.
28. **Heater, Electric Wax.** This unit is used to melt a variety of dental waxes. It maintains them at a workable temperature without overheating.
29. **Heater, Pyroplast® and Oven.** This heater and oven combination is used in the application and curing phases of fabricating acrylic resin restorations.
30. **Investor, Whip-Mix® Vacuum.** This machine is used to spatulate and evacuate air from a mix of gypsum material. It is used primarily for mixing hydrocal to pour impressions and vacuum spatulating investments used in the fabrication of crowns and fixed partial dentures. The vacuum investor is also used to mix alginate impression material.

31. **Jig, Jectron®**. When used correctly, the sectional jig is a fast, accurate way to reline dentures. This technique eliminates the need for flasking and mounting in an articulator, yet produces excellent results.
32. **Lamp, High Intensity**. A high intensity lamp illuminates highly detailed work when room lighting is inadequate.
33. **Lathe, Bench Mounted with Jacobs Type Chuck**. This lathe and chuck combination is used for a variety of grinding, finishing, and polishing procedures in the dental laboratory.
34. **Lathe, Floor Mounted**. This unit is equipped with a suction device to draw smoothing and polishing agents away from the operator. It is used to low speed polish cast removable partial framework, gold fixed partial dentures, and for all types of acrylic resin restorations.
35. **Lathe, High Speed Metal Finishing**. The extremely hard chrome alloy used in removable partial denture construction requires a high speed lathe for finishing and polishing. These lathes are not recommended for finishing gold.
36. **Microblaster and Work Station, Gomco®**. The microblaster has many airabrasive uses. It can be used to remove investment and oxide residue from castings, prepare metal substrate surfaces before and after the oxidation step, prepare porcelain surfaces prior to subsequent firings, cut detailed anatomy into porcelain occlusals, and polish metal surfaces. The unit can use 25 micron to 50 micron size aluminum oxide abrasive or 50 micron glass beads (for polishing). The air pressure is regulated to change the cutting power of the abrasive. Gomco also makes an optional dust collection system that the microblast and work station can use as a base.
37. **Multiplater, Unitek®**. The multiplater is a universal device that can be used for plating tin, silver, and copper. Some of its plating uses include tin plating platinum foil matrices for the bonded alumina crown technique and silver plating impressions for dies and master casts.
38. **Oven, Dehydrating**. Dehydrating ovens are used to dry refractory casts prior to sealing them with beeswax.
39. **Oven, Fixed Prosthetic Burnout**. Electric furnaces are used for wax elimination, preheating, and heat treatment. The paramount requirements of a furnace are:
 - a. An accurate pyrometer.

- b. A method of controlling the rate of temperature rise.
 - c. A positive means of maintaining a constant temperature.
40. **Oven, Porcelain.** A porcelain oven is a specialized unit designed solely for firing porcelain in crown and fixed partial dentures. There are many brands of furnaces manufactured.
41. **Oven, Ticonium® Super.** The Ticonium Super oven burns out up to 22 cases at one time. It has a spring loaded door which opens upward. It is used primarily for burning out removable partial denture framework molds.
42. **Pot, Pressure.** The pressure pot is a device used for curing relines and repairing complete dentures and denture base areas of removable partial dentures when the procedure is accomplished with autopolymerizing acrylic resin. Curing the resin under pressure significantly reduces the possibility of porosity. Lukewarm water (110 to 115 degrees F) is often placed in the pot to hasten polymerization.
43. **Press, Bench Flask.** This press is used for pressure packing acrylic resins into denture molds.
44. **Press, Carrier Flask.** After dentures are packed with a bench press, the flasks are transferred to a carrier press to be placed in the curing unit. The carrier press has two strong stainless steel springs that hold flasks under about 400 pounds of evenly distributed pressure.
45. **Press, Flask Ejector.** The simplicity of operation ensures rapid ejection of the flask from the investment without danger of damage to the prosthesis or flask.
46. **Press, Hydraulic Flask.** The press is used for packing acrylic resin under pressure into denture molds; this press uses hydraulics to apply pressure.
47. **Press, Pneumatic Flask.** This press is for packing acrylic resin under pressure into denture molds. This press uses compressed air to apply pressure.
48. **Pump, Ney® Vacuum.** This pump and similar other pumps are used to evacuate air from the firing chamber of porcelain firing furnaces. Vacuum pressure achieved is normally measured in inches of mercury.
49. **Sandblaster, Paasche® Mini.** The air abrasive gun was designed primarily to clean the inside of gold crowns. It is also used to dull the

occlusal surfaces of castings so the dentist can better judge how they match against opposing teeth. The gun uses fine zircon grit that is driven by a pressurized stream of air. This abrasive removes minute particles of investment and minimizes the need to grind inside the crown.

50. **Scale, Electronic Balance.** This scale is used for precision weighing of casting alloys and wax patterns to estimate the amount of metal required for casting. Scale readout is in either grams or pennyweights. Measurements in pennyweights can be difficult because the scale only records tenths of a pennyweight, which makes conversion to grains necessary.
51. **Scale, Laboratory Balance.** This scale is used for precision weighing. The scale readout is in grams.
52. **Scale, Precious Metal Balance.** This scale is used to weigh precious metals and alloys. Counter weights (used to determine the exact weight of the precious metal or alloy being weighed) are calibrated in grains (grs).
53. **Soldering Unit, Electric.** The electric soldering machine is extremely simple to operate. It is widely used in a dental laboratory because it is ideal for light to heavy electric soldering of precious and nonprecious alloys.
54. **Soldering Unit, Hydroflame.** The hydroflame soldering unit converts water into hydrogen and oxygen to the correct proportion for ideal combustion. An alcohol booster unit is also used in the unit's operation to lower the flame temperatures to a more practical point. The hydroflame soldering unit is particularly suited for delicate soldering operations.
55. **Spot Welder, Electric.** The spot welder uses a high voltage electric current to join two pieces of metal together. This technique is only used on stainless steel alloys. The spot welder's use is primarily in orthodontics.
56. **Steam Cleaner, Williams®.** This steam generator is used to clean the surface of metal-ceramic frameworks and to remove wax and debris from master casts.
57. **Torch, Gas, and Air Casting (Multiorifice Blowpipe).** This torch is used primarily to melt and solder metals and alloys. The gas-to-air ration is easily adjusted to provide the required heat intensity.

58. **Torch, Hanau® Alcohol.** This hand-operated torch is ideal for setting up teeth, waxing, light soldering, and for a variety of uses demanding accurate control of a pointed flame.
59. **Trimmer, Cast.** The cast trimmer is used to trim and contour the casts to a workable size.
60. **Twin Controller, Ticonium.** The twin controller is an electronic device that automatically operates the Ticonium Super Oven or a vertical loading oven. When it is properly adjusted, it activates an oven, maintains a predetermined maximum burnout temperature for specific time periods, and deactivates the oven after the programmed burnout time elapses.
61. **Vacuum Former, Omnivac®.** This unit is a vacuum adapter of sheet plastic. It is used for rapid fabrication of record bases, custom impression trays, surgical bases, mouthguards, nightguards, and temporary fixed partial dentures.
62. **Vibrator.** The vibrator is used to get a mix of a gypsum product to move when you pour impressions and perform various investing procedures. Also, it is used to increase the density of the mix by eliminating air through vibration. A rheostat control is used to adjust the intensity of the vibration from a gentle agitation to a vigorous shaking. The intensity of the vibration is directly proportional to the viscosity of the mix.
63. **Waxing Unit, Micro Matic®.** The micro matic is a precision electronic waxing instrument. It has several different waxing tips that correspond to the conventional hand instruments used for waxing and carving. The temperature of the tip can be controlled to suit the operator's needs.

WEIGHTS AND MEASURES

Carat and Fineness of Gold Alloy.

- a. **Carat.** Information giving the amount of pure gold in an alloy is usually supplied by the manufacturer on the gold wrapper. It may be stated in terms of either carat or fineness. If it is given in carat, you may think of the unit of gold as being divided into 24 smaller units. The number of these small units which are pure gold is the carat number. If the alloy is 12 carat, 12 of the 24 parts, or 50 percent, are pure gold. If it is 24 carat, it is all gold.
- b. **Fineness.** The fineness of an alloy is the parts per 1,000 which are gold. If it is 750 fine, then 750 of these parts, or 75 percent, are pure gold; 500 fineness is exactly one half, or 50 percent gold.
- c. **Conversion.** Carat is the number of parts of gold in 24 parts of alloy, fineness is the number of parts of gold in 1,000 parts of alloy, and percent is the number of parts of gold in 100 parts of alloy. A simple method for converting the carat to fineness or the fineness to carat is to use this formula:

$$\frac{\text{Carat}}{24} = \frac{\text{Fineness}}{1,000}$$

Carat	Fineness	Percent
24	1000	100
22	916	91.6
20	833	83.3
18	750	75
16	666	66.6
14	583	58.3
12	500	50
10	416	41.6

Measuring Temperatures:

- a. **Scales.** Temperatures are commonly measured on a Fahrenheit (F) scale where 32 degrees is the freezing point of water, and 212 degrees is the boiling point, or on Centigrade (C) scale, where 0 degrees is the freezing point and 100 degrees is the boiling point.
- b. **Conversion.** Centigrade can be converted to Fahrenheit or vice versa by means of the formula $9C = 5F - 160$.

Systems of Measuring Weights. There are four different systems of weight measurements which are used in the dental laboratory:

- a. **Avoirdupois** - commercial
- b. **Apothecaries'** - medicine and drugs
- c. **Troy** - precious metals and alloys
- d. **Metric** - some pharmaceuticals, such as alcohol. The grain is the basic unit in the avoirdupois, apothecaries,' and troy systems, but not in the metric system.

Measurements of Length. The metric system of measuring is the most universally used in dental measurements.

Measure of Liquid or Volume.

- a. The basic unit of the metric system of liquid measurement is the cubic centimeter (cm³) or milliliter (ml). One cm³ of water at 39.5° F weighs 1 gram.
- b. Either the apothecaries' wine measure or the metric system is used to measure the volume of liquids.

Gage Standards. Gage is a measure of thickness that can be applied to metal wire, sheet metal, wire wax, and sheet waxes. Brown and Sharpe Gage or American Wire Gage (the two are the same) represent a standard for wire and sheets that do not contain iron.

Melting Points of Pure Metals. The melting point of aluminum is 1218° F, gold is 1945° F, lead is 621° F, and silver is 1761° F.

GLOSSARY OF TERMS

Abrasive – A range of coarse to fine granules with sharp edges used for smoothing, grinding, or polishing.

Abutment Tooth – On removable partial dentures, it is the tooth on which a clasp is placed to support and retain the removable partial denture. On fixed partial dentures, it is the tooth to which the retainer casting is centered.

Accelerator – A chemical agent that speeds up a chemical reaction.

Acid – Any one of a group of corrosive chemicals used to clean oxide layers or surface contaminants from gold castings.

Agar-Agar – A gelatin-like substance obtained from certain seaweeds and used in compounding reversible hydrocolloid impression materials.

Alginate – An irreversible type of hydrocolloid made with salt of alginic acid.

Alveolar Process – That specialized part of the mandible and maxilla that surrounds and supports the roots of natural teeth.

Alveolar Ridge (Residual Ridge) – The residual ridge is the remnant of the alveolar process which originally contained sockets for natural teeth. After natural teeth are extracted, the alveolar ridge can be expected to get smaller (resorb). The rate of resorption varies considerably from person to person.

Alveolus – The bony socket that holds the root of a tooth by the periodontal ligament.

Anneal – To control the heating and cooling of a metal in a way that makes it soft and ductile.

Anterioposterior – Extending from the front, backward.

Anterior Tilt – A term used in surveying the master cast. When the cast is tipped on the surveyor table so the anterior part of the cast is down, it is called an anterior tilt.

Apothecaries' Weight – The system of weights used in dispensing drugs. The basic unit is the grain.

Aqua Regia – A mixture of three parts hydrochloric acid and one part nitric acid. Gold is soluble in aqua regia.

Articulator – A mechanical device representing the temporomandibular joints and jaw members to which casts of the mouth can be attached for performing prosthodontic procedures.

Baseplate Wax – The thin sheets of wax used to wax up dentures and trays and for many other purposes.

Beading (Cast) – To score a cast in any desired area to provide a seal between the finished prosthesis and the soft tissue.

Beading (Impression) – To rim an impression with a wax strip before pouring so that all critical impression landmarks show up in the cast.

Bennett Movement – The lateral bodily shift of the mandible resulting from movement of the condyles on the lateral inclines of the temporal fossae when the mandible moves laterally.

Bevel – The slope or slant of a surface or edge.

Boley Gauge – A caliper-like instrument calibrated in millimeters and used for fine Boxing an Impression – The matrix of wax wrapped around the impression for confining the plaster or stone as the cast is poured.

Buccal Frenum – The string-like tissue which attaches the cheeks to the alveolar ridge in the bicuspid region of each arch.

Cementum – A soft, bone-like structure covering the root surface of the tooth.

Centric Relation – The relationship of the lower and upper jaw in rest position.

Clinical Crown – The part of the tooth visible in the mouth.

Condylar Guidance – A device on an articulator which is intended to produce guidance in the articulator's movements similar to that produced by the paths of the condyles in the temporomandibular joints.

Condyle – The rounded articular surface at the articular end of a bone.

Contour and Fullness of Lips and Cheeks – The fullness required in the occlusal rims to restore the natural appearance.

Convex – A surface which is curved outward toward the viewer.

Crossbite – In posterior areas, a reversal of the normal stamp cusp to opposing fossa relationships. Opposing anterior teeth are said to be in crossbite when normal horizontal overlap is reversed.

Curve of Spee – An antero-posterior curve, determined by following the incisal edges and cusp tips of the mandibular teeth, when viewed from the side.

Dentin – The tissue of the tooth underlying the cementum of crown which makes up the bulk of the substance of the tooth.

Diastema – A space between the teeth. Most commonly a space between the upper central incisors.

Die – A positive reproduction of a prepared tooth, made from a suitable, hard substance (improved artificial stone or metal). A die can be constructed from a complete arch, partial arch, or individual tooth impression.

Distal – A surface facing away from the midline of the mouth; the distal surface of a tooth.

Eccentric – Off center.

Embrasure – A space around two teeth created by the sloping away of the mesial and distal surfaces from the contact point. The space is divided into occlusal, incisal, facial, lingual, and gingival areas.

Enamel – The white, compact, very hard substance that covers and protects the dentin of the crown of teeth.

Extrinsic – Outside, as opposed to intrinsic or inside.

Facebow – A device used to record the relationship between the maxillae and the temporomandibular joints and to transfer this relationship to the articulator.

Facebow Transfer – A procedure used to mount a maxillary cast in an articulator in the same way the maxillae relates to the temporomandibular joints.

Fixed Prosthesis – A fixed prosthesis is any of a variety of replacements for a missing tooth or a part of a tooth that a dentist cements in place and one the patient cannot remove. Restorations such as inlays, pinledge castings, onlays, crowns, and fixed partial dentures fall into this category.

Fovea Palatina – One or two small indentations in the region of the junction of the hard and soft palates formed by a coalescence of mucous glands.

Gingiva – The gum tissue.

Hamular Notch – A deep depression located posterior to the maxillary tuberosity. The depths of this depression is part of a series of guides used to determine the posterior border of a maxillary denture.

Hard Palate – The anterior two-thirds of the roof of the mouth composed of relatively hard, unyielding tissue.

High Lip Lines – Serves as a guide for length of the central incisors.

Hydrocal – A form of gypsum that is harder and more durable than ordinary dental plaster.

Hydrocolloid – An impression material used extensively in dentistry. It may be reversible agar type or irreversible alginate type.

Hygienic Pontic – A pontic wherein its closest approach to the residual ridge is no more than 2 mm.

Incisal – Pertains to the cutting edge of the anterior teeth.

Incisal Papilla – A small pad of tissue, that is located at the midline just behind the crest of the maxillary ridge which protects the vessels and nerves as they exit from the incisive foramen.

Interproximal – Between adjoining tooth surfaces.

Interproximal Space – The space situated between two adjacent teeth.

Labial – Pertaining to the lips. The surface of an anterior tooth opposite the lips.

Labial Frenum – The connective tissue which attaches the upper or the lower lip to the alveolar ridge at or near the midline of both the upper and lower jaws.

Lingual Bar – The metal piece of a major connector used to connect the right and left sides of a lower removable partial denture. It is contoured to the lingual tissue behind and below the anterior teeth.

Major Connector – A part of a removable partial denture framework which connects one side of the appliance with the other. A lingual bar is an example.

Malleability – The property of a metal which permits it to be extended in all directions without breaking.

Margin – The border or boundary, as between a tooth and a restoration. Also, the outer edge of a crown, inlay, or onlay.

Matrix – The mold in which something is formed.

Maxilla – The upper jaw.

Maxillary Tuberosity – The maxillary tuberosity is the most distal (posterior) portion of the maxillary alveolar ridge.

Mesial – The surface of a tooth nearest the midline in a normal occlusion.

Midline – Designates the midline of the mouth.

Noble Metal – A metal not readily oxidized at ordinary temperatures or by heating, for example, gold or platinum.

Obturator – A prosthesis used to close an abnormal opening between the oral and nasal cavities.

Occlusal Plane – The plane established by the occlusal surfaces of the bicuspid and molars of both the upper and lower jaws in opposition. May also refer to the same plane established in the occlusion rims.

Occlusion – Any contact between opposing cutting or chewing surfaces of maxillary and mandibular teeth.

Opaqueing – Covering the metal work of a prosthesis with a material so it does not show through a thin veneer of acrylic resin or porcelain.

Orientation of Occlusal Plane – The location of the position which the occlusal plane is to occupy between the upper and lower ridges.

Oxidation – The process in which a metal substructure is heated in a porcelain furnace to cleanse the porcelain-bearing surfaces of contaminants and produce an oxide layer for porcelain bonding.

Palatal Bar – The metal piece of major connector contoured to the palatal tissue and used to connect the right and left side of an upper removable partial denture.

Palate – The roof of the mouth.

Paraffin – A white, waxy hydrocarbon distilled from coal or petroleum and used to compound several dental waxes.

Plaster of Paris – A gypsum that is refined by grinding and heating.

Polymerization – The reaction which takes place between the polymer and monomer during the curing of the acrylic resin.

Porous – To be pitted; not dense; containing voids and bubbles.

Posterior Palatal Seal – A carved depression in the cast which improves retention of the maxillary denture.

Removable Partial Denture (RPD) – A removable replacement for missing natural teeth, gingival tissue, and supporting bone when one or more natural teeth still remain.

Resin – A gummy substance obtained from various trees. It is used to make many dental materials.

Retromolar Pad – The soft tissue pad at the posterior extremity of the mandibular ridge.

Ridge – A linear elevation of enamel on the surface of a tooth, for example, a marginal ridge. Also, in prosthodontics, the alveolar ridge: the area of the upper and lower jaws formerly occupied by the natural teeth.

Ridge Lap – The area of an artificial tooth which normally overlaps the alveolar ridge. It corresponds on the inner surface of the denture tooth, approximately to the location of the collar on the facial surface.

Root – The portion of the tooth that is covered with cementum.

Rugae – The elevated folds or wrinkles of soft tissue situated in the anterior part of the palate.

Sagittal Plane – The plane that divides the body vertically into two equal halves.

Soft Palate – The posterior one-third of the roof of the mouth. It is composed largely of moveable soft tissue.

Sprue – A cylinder of metal or wax attached to the wax pattern of an onlay, crown, or removable partial denture, which later is withdrawn or removed from the investment, leaving a passage into the mold.

Sulcus on a Tooth – A linear depression in the surface of a tooth, the surfaces of which meet at an angle. A sulcus is always found along the surface of a developmental line.

Surveyor – An instrument used to locate and mark the greatest circumference of one or several abutment teeth at a given tilt of the cast. Also, used to locate soft tissue undercuts at a given tilt.

Troy Weight – The system of weights used in dentistry for weighing gold. The basic unit is the grain; 24 grains are equal to 1 pennyweight.

Tuberosity – An area in the form of a bulge, at the posterior end of the maxillary alveolar ridge.

Vertical Dimension – The amount of jaw opening.

Vestibule – The part of the mouth that is between the cheeks or lips and the alveolar ridge.

Vibrating Line – A line in the soft palate that marks the junction between tissue, which moves, as in swallowing, and that which is stationary.

Zinc Oxide – A powder incorporated with eugenol or a similar oil to form a mild antiseptic and analgesic paste. It is a constituent of most impression pastes.