Through a glass darkly...
Dr Chris Weber, President at Dr Hazmat, suggests that clandestine lab investigation could be more transparent.

You've been asked to help, yet again, with a suspected meth lab investigation for the state's methamphetamine response team, but this time the lab looks different! The equipment just doesn't look the way it has in the past, moreover the equipment and glassware that is there isn't hooked up in any way that you've seen before. What is going on here? What do you do now?

Clandestine or illicit laboratories are secretive and illegal production facilities that can be configured to make drugs, explosives, chemical agents and/or biological agents. Some of the materials produced in these labs can obviously be extremely dangerous. Even illicit drug labs, which in theory produce products intended for human consumption, pose significant chemical hazards in terms of flammability, corrosivity and toxicity—primarily from the reagents and precursors necessary for the drug synthesis. Illicit drug labs will contain, to varying degrees, professional grade, laboratory glassware and improvised equipment to produce the illicit materials. The glassware and equipment found in these labs can be likened to the pots and utensils used in a kitchen; the chemical precursors, reagents and solvents can be likened to the ingredients found in a kitchen. Both of these components are critical for a responder to determine what is being produced and at what stage the production process is in.

It is extremely important to have at least a rudimentary understanding of the glassware, equipment and precursors that are commonly encountered in illicit laboratory response. Early recognition of processes, especially labs involved in the production of explosives and particularly dangerous drugs such as PCP or fentanyl, could save your life. The key to laboratory hazard assessment is the rapid and accurate identification of a lab's glassware, equipment, processes, recipes, directions and chemicals. As mentioned, the synthesis of chemicals can be likened to the process of cooking food in the kitchen, insofar as when you make your favorite dish you will also need appropriate ingredients (reagents and precursors), appropriate kitchen utensils (glassware and equipment) and a good recipe.

The products produced in illicit labs use a variety of chemicals for a variety of purposes. Precursors are essential chemicals that are incorporated into the final molecule and form its core, such as pseudoephedrine in the most common method of methamphetamine synthesis. Essential precursors define not only the final product being produced, but also the method by which it is produced. For example, phenyl-2-propanone is the precursor for an alternative method to the more common pseudoephedrine methods of meth production. Reagents are chemicals that perform an essential role in the production process and are destroyed during that process, such as lithium metal in meth production. Catalysts are chemicals that also play an essential role in the production process, but do not get used up in the reaction, such as red phosphorus in meth production. Solvents are the medium in which the reaction occurs and do not get incorporated into the final product. Red phosphorus, iodine, and pseudoephedrine are all examples of solids and, in order to efficiently react, they must be dissolved in a suitable solvent. The combination of chemicals present in an illicit lab is a critical indicator of a lab's type, as well as the dangers it poses to you and the public.

The glassware found in these labs will be either professional grade or homemade and improvised, or possibly a mixture of the two. Professional laboratory glassware in expressly designed for certain chemical processes and is very efficient at performing these functions. A common myth is that most illicit labs will have improvised glassware due to a perceived limited availability and high cost of the lab grade equipment. This is certainly not the case any more, especially after the advent of Internet sites such as eBay.

Continuing with the kitchen analogy, illicit labs need storage containers in which to hold the ingredients, containers in which to combine the ingredients, and containers in which to produce the final product. Round bottom flasks are very common pieces of glassware that are used in illicit labs to heat, cool or hold chemical processes or their results. Round bottom flasks are the culinary 'pots' of labs. Every good pot needs a lid and condensers, which are jacketed hollow glass tubes, are highly efficient lids. During use, the jacket is typically filled with cooling water, which leads to the condensation of the vapors inside it into a liquid. The condensate is then collected at the bottom in another round bottom flask. Typical glass, plastic and metal containers are used to store the chemicals before and after use. Thermometers are used to monitor the temperature of reactions and distillation processes. Adaptors, such as vacuum adaptors and distillation heads, are used to connect glassware in the appropriate
sequence to carry out a chemical process.

The types of glassware and processes found in any given lab are very indicative of the types of materials being produced, especially chemical versus biological products. Chemical, illicit labs typically use significant amounts of glassware, as well as heating and cooling equipment, to manipulate chemical reactions. Some of the chemical processes you may encounter in an illicit chemical lab include reflux reactions, simple distillation, fractional distillation, liquid-liquid extractions, solid-liquid extractions and cooling baths. The way the glassware and equipment is connected and used differentiates these processes.

Reflux reactors are used to heat reagents in order to speed up one or more reactions that produce the desired product. A reflux reactor consists of a round bottom flask and a condenser column hooked together in a vertical configuration with a heating element located underneath the flask. Reflux reactors may also have a thermometer to monitor the reaction vessel temperature and may be connected to a scrubber to mitigate hazardous gaseous byproducts. The round bottom flask is the pot, the heating element is the stove, and the condensing column is the lid. If you keep this analogy in mind it will be much easier to spot an unconventional reflux reaction amid a chaotic, clandestine lab. The red phosphorus/iodine methamphetamine production method (Nazi method) uses a reflux reactor to convert the pseudoephedrine into methamphetamine.

Distillation processes are used to separate chemicals from one another, such as the final product from the reaction mixture, an impurity from the final product, or a reaction intermediate from the reaction mixture. It is worth noting that it is impossible to tell where the final product is in a distillation process unless additional information is known about the identity of the final product and the production method being employed in the synthesis. The most volatile of the components will be found in the receiving flask. At any given time this may or may not be the final product. Distillation processes are found in illicit labs, especially chemical agent labs, that require a highly pure final product for dissemination purposes or stability purposes.

Extractions are used to remove one material from another. In chemical processes, liquid-liquid extraction is used to purify the final product or a reaction intermediate. The separation funnel is commonly used to separate an aqueous or water soluble material from a non-aqueous or water insoluble material. Separatory funnels, whether homemade or professional grade, are used in methamphetamine laboratories to remove the meth oil from the crude reaction mixture. In toxin laboratories, solid-liquid extraction, such as a Soxhlet extractor, can be used to remove a toxin from the plant material, as is the case with nicotine extraction from tobacco leaves.

Some reactions are extremely exothermic (heat producing) and/or the reagents or products are heat sensitive (such as with certain explosives). These reactions require constant cooling rather than heating (as in a reflux reaction). Cooling baths may consist of a combination of ice and water or may be more complicated, such as a dry and acetone bath. Explosive labs - both the organic peroxide and nitrate explosive variety - will typically contain cooling processes, such as ice baths.

Biological laboratories are designed to discover, verify, isolate, grow and weaponise biological agents such as bacteria and viruses. Biological labs look very different from chemical labs. Biological processes have the growth and propagation of living organisms as their centerpiece, therefore there are very few elevated temperature processes in use, with the notable exception of sterilisation or autoclaving, which is used to kill unwanted living organisms that would interfere with the growth of the desired pathogen. Most human pathogens are grown at body temperature: 37°C or 98.6°F. There will, therefore, be incubators of various shapes and sizes designed to serve as a hospitable home for the target organism. Biolabs are also notable for their general lack of flammable and corrosive chemicals. The most common chemicals found in biolabs are food for the organisms (such as protein extract) and water based solutions and buffers to keep the pH of the broth near neutral. Broth is the term for the nutrient solution in which the pathogens grow and multiply.

Toxins are poisonous chemicals extracted from living organisms. Toxin labs often appear to contain elements of both the biological labs and the chemical labs. The biological side of the lab is used to grow the organism from which the toxin will ultimately be extracted. The extraction process can initially appear to be a chemical lab, especially if the toxin is a small molecule, such as nicotine, rather than a large protein molecule, such as ricin.

When responding to illicit laboratories it is imperative to determine, as quickly as possible, what type of lab is being dealt with. The first step is to classify it as a chemical lab (drug, explosive or chemical agent production), a biological lab (bacterium or virus production), or a hybrid lab (toxin production). After the lab category has been determined, it will then be necessary to determine the family of chemical or biological agent being produced through observation of the general category of chemicals and production equipment that is present, e.g., drug, explosive, or bacterial agents. Once the family has been determined, the identity of the material can be ascertained by determining the precursors and reagents present using sample identification equipment such as Raman and FTIR spectroscopy. When responding to illicit labs, always be aware of the dangers the 'cooks', booby traps, hazardous chemicals and improperly configured lab equipment can pose. It is best to take a slow, systematic approach to illicit lab investigations, both for safety reasons and for evidence preservation.