6 Opinions

A clandestine lab is a Pandora's Box of illegal activities. Controlled substances are produced using household chemicals mixed with ordinary utensils in what some have called a "kitchen of death." What appears at first glance to be simply atrocious housekeeping or even just a hobby gone awry may actually be the final step in the production of many of the drugs sold on the street or the explosives used in various forms of domestic terrorism.

Everyone has his own image of what a clandestine lab would look like. The man on the street, from which a typical pool of jurors is drawn, will more than likely report images of smoking and boiling chemical reactions using scientific equipment in a hidden laboratory, such as Frankenstein's birthplace. As has been demonstrated in the previous chapters, this is far from the case. An expert is called to understand what he sees at the crime scene and to draw a mental picture for others as well. Remember that all experts are, first, investigators, but not all investigators are able to become experts.

A forensic expert must first assemble enough pieces of physical evidence to demonstrate that a clandestine lab exists. He must be able to combine the known facts to present a scenario of the "What? Where? Why? and How?" of the operation. His knowledge base is broad enough to acknowledge that other explanations could exist for the combination of chemicals and equipment found at a location. He considers the totality of circumstances of the case and concludes with a schematic of the most likely arena in which the manufacture of a controlled substance took place.

Forensic evidence and the opinions generated by it are used to supplement or answer the basic *Who? What? Where? When? Why?* and *How?* questions involved in any criminal investigation. While able to address objective questions, there are still limits on subjective ones. The expert's job is to use the forensic evidence to compile, evaluate, and render an opinion concerning the facts of each case as presented. The expert may be involved in the case from the beginning, or he may be brought in at the end to evaluate other expert opinions. Either way, the process is basically the same.

In Chapters 4 and 5, the forensic chemist who was trained in clandestine lab issues was presented as the ultimate expert. He has a significant knowledge base to draw from in presenting expert testimony and generating opinions. However, he is not the only source of expert opinions. Criminal investigators, bomb technicians, and hazardous materials specialists who regularly deal with clandestine lab issues can generate qualified opinions. While such individuals may not know the specific theories concerning the chemistry involved, their experience and training provide the knowledge base that a given set of chemicals and equipment can be used to produce a controlled substance.

In this chapter, the opinions generated by experts that are used during arrest and prosecution of clandestine labs are addressed. From the forensic evidence collected, experts are able to study a clandestine lab and afford opinions to the Court. Further addressed in this chapter are the evaluation and the opinion-making processes, and hopefully, insight will be provided into them. Sources of information that are needed to formulate an opinion will be listed. Questions the forensic expert needs to derive from that information will be addressed. These questions most significantly include the following:

What is the operator making?
How is the operator making it?
How much (quantity) could the operation produce?

6.1 The Questions

Clandestine lab experts are forensic investigators who come from a variety of functions within the criminal justice community. They may be peace officers or forensic chemists. They may or may not carry guns and have arrest authority. Whatever their functions, their missions are basically the same — collect and objectively evaluate information concerning a clandestine lab operation.

The expert must deal with the same *Who? What? Where? When? Why?* and *How?* questions as the investigators. Experts simply approach the question from different perspectives. Combining information concerning physical evidence and scientific principles to objectively evaluate the operation is their forte, and they use this straightforward angle of the case to formulate and provide their opinions. Some questions can be answered at the scene; others can only be addressed and determinations made after the laboratory examination is complete. The expert uses this combination of answers to all of the questions to form his ultimate opinion concerning the operation as a whole.

The opinion process begins with the affidavit for a search warrant. Using the information provided by the lead investigator, the expert renders an opinion as to whether there is sufficient information with which to establish the existence of a clandestine lab. The expert's opinion is a key factor in this part of the legal process, and it is used to support the investigator's conclusion of the facts. If flawed, the opinions presented could later be raised in court by defense counsel as "motions to suppress evidence" due to lack of probable cause. It is, therefore, necessary to exhibit extreme care when determining that certain conditions exist and that they point irrevocably in the direction of a clandestine lab operation.

Experts talking to investigators about what (on the surface) seems to be a general opinion about clandestine labs would be well advised to document these conversations. The expert's name may be placed into an affidavit without his knowledge. The statements attributed to him may be totally wrong, misinterpreted, or even never uttered in the first place. His supporting documentation of what was said during the preliminary conversations may become necessary if the expert is asked about statements he made in the search warrant affidavit. Obviously, this could crucially affect his future credibility.

The search of the suspected clandestine lab site is the pinnacle of the investigation. Emotions run high, people may be stressed and tired, and answers are demanded. Before an expert gets out of his car, investigators want to know: *What are they making in there? How are they making it? How much product is there? How much could they make in a...?* Unfortunately, many novice clandestine lab investigators really expect answers to these questions immediately.

In these instances, the expert does not have sufficient direct knowledge of the situation to render an opinion. At best, he should only make qualified generic statements concerning what could be made and possibly how it was being made, using the limited information he has. The chaos of a clandestine lab scene does not provide an atmosphere in which to render any type of objective opinion. Opinions concerning the specific details of the operation should be rendered only after the physical evidence can be evaluated in an objective manner, which is after the fact only.

Many types of opinions can only be generated from the laboratory analysis of evidentiary samples. Some are a result of generalities that do not require the support of analytical data. For example, just because a red powder is found at the scene of a suspected ephedrine reduction lab does not make the powder the critical red phosphorus. It is essential that if an analytical chemist is going to render an opinion concerning a clandestine lab, he must have the analytical data to support it.

The forensic expert must remember the laboratory analysis, and his opinions should be able to withstand peer review. A component chemist or other forensic expert should be able to review the facts of the case or the laboratory data and draw the same conclusion as that of the original expert. Alternative opinions can and do exist, as is evidenced by prosecution and defense differences. But the information must support the opinion, or the opinion is worthless.

6.1.1 Who?

One of the initial questions in any investigation is: *Who was involved?* This simple investigative question can be answered to one degree or another by looking at the people detained or living at the scene. Placing them at the scene is one thing but connecting them to the lab operation may take a forensic expert. Latent prints can be used to establish who had access to the lab equipment and chemicals. In some instances, laboratory analysis of a suspect's clothing can be done to detect drug and chemical residues, which can be used to connect him to a lab operation. The analysis of the handwriting on paperwork associated with the operation can also be used to establish a link between the operation and people who were nowhere near it at the time of seizure.

6.1.2 What?

The most common what question is, *What are they making?* Asking the operator is the easiest way to obtain this information. However, operators have been known to be less than truthful, uncooperative, or simply unaware of the identity of the final product. That is where the forensic expert comes into play. He combines the information from the paperwork, available chemicals and equipment, as well as the laboratory analysis of items associated with the operation to provide an objective opinion concerning what was being produced.

Some lab operations perform only a portion of the process. This is done to avoid compromising the entire operation. In these instances, the *What step in the process are they?* question may play a significant role in the investigation. The expert utilizes the same information to determine what was being made and then rolls that information into an opinion concerning in what stage of the process was the operation.

6.1.3 When?

When were they cooking? This is not a question that is conducive to traditional forensic techniques. Other than being caught in the act, the forensic expert cannot provide much insight. Traditional investigative techniques provide the best methods of answering this question.

6.1.4 Where?

Where was the lab? The location of all or any given segment of the operation can be determined through forensic investigation. The position at the scene of the lab, the chemicals, or where the equipment was located can easily be documented. Forensic investigation and analysis can demonstrate where each portion of the process was conducted as well as where the suspect was putting his waste products. Even if the lab was dismantled and removed from a location, analyses of the residues left on floors, or even stains left on the walls and counters, can be used to determine where the lab was located and what was being produced. Shown in Figure 6.1 is an example of how the location of a makeshift ventilation system can be used to demonstrate the location manufacturing operation.

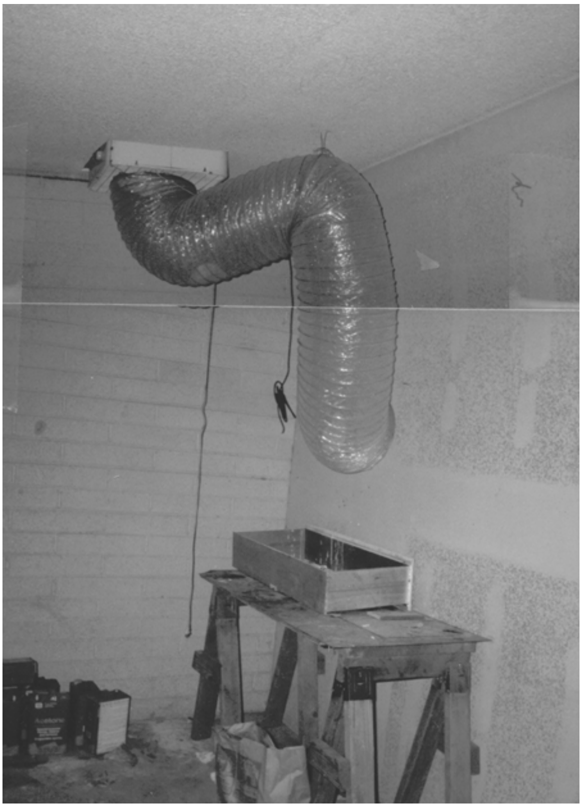

Figure 6.1 Makeshift ventilation.

The questions, *Where was he getting his chemicals and equipment?* or *Where was he storing excess chemicals and equipment?* can be answered by reviewing documents seized from the scene or other locations associated with the operation. Operators are generally pack rats and save everything. Where you will find evidence concerning the operation is only limited to the imagination of the operator and the investigator searching the scene.

6.1.5 Why?

On the surface, *Why?* is a simple question to answer. Money, drugs, or both is the answer to the basic *Why are they manufacturing?* question. However, the forensic expert needs to dig a little deeper and ask a few more questions in this same vein: *Why did the operator use this method of manufacture? Why did he use a particular chemical supplier? Why did he use the equipment he used?* The answers to most of these *Why?* questions is subject to conjecture. However, experts, by their nature, have the latitude to speculate. They are expected to use their training and experience to evaluate the facts of the case and present an educated theory concerning the why's of the operation.

6.1.6 How?

Many of the "How" questions need a technical expert to answer. They all have the potential to be asked in court. The lead investigator may want on-the-spot answers to many of the same questions. Unfortunately, many can only be completely answered after laboratory analysis and data interpretation. The how questions include: *How were they making the product? How much product was there? How much could they make per batch or over a given period of time? How much could they make with the seized chemicals and equipment?*

6.2 Information

Information is key to answering any question. Answering questions without information is like putting a puzzle together without enough pieces. With a puzzle, the more pieces that exist, the closer to the complete picture that is created. The more information an expert knows about a clandestine operation, the closer he can come to painting a complete picture of the operation.

The clandestine lab expert has a needs triangle similar to that of the clandestine lab operator (Figure 6.2). The clandestine lab operator needs chemicals, equipment, and knowledge to make the operation work. The clandestine lab expert needs information from the scene, from the laboratory analysis, and from the knowledge gained from training and experience. Scene information provides knowledge concerning the operation in general. Labora-

Figure 6.2 The opinion needs triangle.

tory analysis provides information concerning the specifics of any given sample. The expert's experience and training allows him to piece together all the information to complete the picture of the operation.

6.2.1 Scene Information

The information gathered at the scene of a clandestine lab has a number of functions. First, it corroborates the prior information used to establish probable cause in obtaining the search warrant. Second, it guides the direction of the on-scene investigation. Third, it helps the analytical chemist devise the analytical schemes he will use during the testing of the samples that are sent to the laboratory. Finally, it will be used as a basis for the expert's testimony concerning the workings of the operation.

The information gained during the initial scene walk-through sets the tone for the balance of the scene processing. The expert's initial impressions of what the operator was making and how he was making it help to determine what type of search will be conducted. Drug labs may take one approach. A cautious and different path may be necessary with suspected explosive labs. If no lab is initially apparent, a different search tactic is taken.

The common thread in all searches is that the observations and the physical evidence guide the on-scene investigation. The desire to put someone in jail should not be so great that the expert misinterprets or misrepresents the presence of common items to justify the presence of the police. Search warrants for the wrong location have been granted on poor information. This situation should never deteriorate to where the forensic expert is looking for whatever evidence it takes to allow the law enforcement agency to save face. On the other hand, even if the operation is not readily apparent, the forensic expert should be as creative in his search techniques as the operators are in hiding and disguising the labs.

The analytical chemist uses the information provided by the scene chemist or expert to devise his analytical schemes. He reviews this information to determine what samples require examination and what types of testing are appropriate. The analytical chemist also uses the scene information to estimate the amount of final product the operation could produce. This information can also explain reaction by-products that are not normally encountered in the reaction mixtures from that type of lab.

The opinions rendered from scene information are forensic evidence, and they must stand up to peer review. Documentation of the observations made at the scene is a critical component. Photographs, sketches, and inventory lists can be used to support the expert's opinions rendered in the report. An independent expert should be able to review the scene documentation and come to the same conclusion as the person generating the report. That is not to say that the independent expert may have a differing opinion, only that the documentation supports the report's conclusion when looked at by outside review.

The scene chemist must take care not to overstate his opinions concerning the scene. It is easy to get caught up in the frenzy of the moment and provide an opinion that is not completely supported by the facts. Producing a written report, after he has had time to objectively evaluate all of the information concerning the operation, is the wisest method of disseminating the opinions concerning the operation. The written report should contain information concerning his role in the scene processing as well as his opinion concerning his observations thereof. The criminal investigators, analytical chemists, and prosecuting and defense attorneys use this information to guide their investigations or to prepare their case for trial. The report should state more than a final conclusion of the expert opinion. There should be some narrative explanation of how the expert reached the conclusion.

In some instances, the expert's report will be the only expert evidence presented. The court should be given some explanation of how and why the expert came to his conclusion. A scene report containing a simple summary statement such as: "The items found at 123 Oak Street were consistent with those found at a clandestine lab that manufactures a controlled substance" does not provide other parties involved in the investigation or prosecution sufficient information with which to use to continue with their portion of the investigation.

The previous statement may be a valid conclusion. However, it is too generic and does not provide the reader a sense of what was being manufactured or information to support his statement. A better statement that summarizes the observations made by the scene expert would be: "The items found at 123 Oak Street were consistent with those found at a clandestine

Table 6.1 Information and Opinion Relationship

Information	Conclusions
Chemical inventory	Used to establish the manufacturing method and the overall production capability of the operation
Equipment inventory	Used to establish the manufacturing method and the per batch capability
Location of the items at the scene	Used to establish the location of each portion of the process at the scene
Original volumes or weights	Used to establish the actual amount of product seized
Seized paperwork	Used to provide a historical perspective of the operation; some operators are detail oriented enough to keep records concerning the percentage yield of each batch
Chemical receipts	Used to provide insight into the amount of chemicals purchased over a period of time

lab that was manufacturing tetra-ethyl-death using the shake and bake method." This wording allows the scene expert to say that in his experience, the items that were observed at the scene were the same as those found in operations that produced a certain controlled substance using a particular manufacturing method. It also provides for the option for alternative manufacturing theories.

A large quantity of information can be derived from the scene. This information can be used to render limited or generic opinions concerning the operation and its capabilities. It will also be evaluated at a later time to establish the particulars of the operation under investigation. Presented in Table 6.1 is a relationship between information that can be obtained at the scene and opinions that can thus be generated.

6.2.2 Laboratory Analysis Information

The information from the scene provides the pieces of the clandestine lab puzzle and a generic outline of how they fit together. Laboratory analysis provides detail for each piece. It fills in the holes and provides answers to any questions generated during the scene investigation. Laboratory analysis supports or refutes the opinions generated at the scene. In some instances, laboratory analysis generates additional questions, requiring supplemental information from investigative sources before a complete opinion can be rendered.

With laboratory analysis, information concerning the identification of the controlled substances being produced as well as the precursor and reagent chemicals located at the lab site is provided. It aids in identifying by-products in the reaction mixtures and the waste products that may be used to establish a particular manufacturing method. Laboratory analysis produces the quantitation data that can be used to calculate the amount of controlled substance present in reaction mixtures and to estimate its production values.

6.3 Experience and Training

All clandestine lab chemists are forensic chemists. However, not all forensic chemists are clandestine lab chemists. A clandestine lab chemist has the training and experience to render an opinion concerning the existence of a clandestine lab given a certain set of facts. Volumes of information can be generated from a clandestine lab case. The expert trained in clandestine lab matters is able to wade through this to determine which pieces of the puzzle are relevant and which pieces are superfluous.

To be an effective clandestine lab expert, a chemist must have a solid background in basic organic, inorganic, and analytical chemistry. He also should be well schooled in the techniques underground chemists utilize to manufacture a wide range of controlled substances. Finally, he should have access to a variety of analytical databases so that he can cross-reference his analytical information to reduce it to its most logical scenario given all of the known facts. This last is a skill that is only learned over time. In some instances, it is an art based on science and experience.

Presently, there is no formally developed complete course of instruction to train a clandestine lab chemist his trade. Clandestine lab chemists are like the forensic drug chemists of the past. Under ideal circumstances, they serve an apprenticeship under an experienced forensic drug chemist who mentors them in the applications of the analytical techniques of chemistry and forensic science for the examination of clandestine lab evidence. Under less than ideal circumstances, the drug chemist is given a clandestine lab case and is expected to do the analysis and provide the opinions because he is the most qualified (or in some cases the only) chemist available, and by virtue of his education, he is the resident expert.

There are instructional programs that address segments of the forensic clandestine lab investigative process. The Drug Enforcement Administration and the California Criminalistics Institute have programs designed specifically for drug analysis or generic clandestine lab response. These programs only provide the tools that loosely address the issue of the analysis and interpretation of evidence from clandestine labs. Even with this training, the chemist must rely on real-world experience to gain the knowledge necessary to make the tools gained in his basic training effective in his work.

6.3.1 What? How? How Much?

All of the *Who*? *What*? *When*? *Where*? *Why*? and *How*? questions an expert needs to address can be boiled down into three basic questions. The answers to all of the other questions will fall into place if the expert at the scene investigation or the analytical chemist performing laboratory analysis can focus on addressing these questions. These three main questions are: *What is he making? How is he making it? How much can he make?*

Answering these questions is not the "be all and end all" of the forensic investigation. The answers generally lead to additional questions that need to be addressed. However, they point the forensic investigator in the direction the investigation should go.

6.3.2 What Is He Making?

On the surface, the answer to this question is relatively easy to ascertain. The analysis of the final product quickly and definitively establishes what the operator was making. Laboratory analyses confirming the presence of a drug or an explosive make a strong argument in favor of one type of manufacturing operation or another.

Establishing the identity of the final product in operational labs that do not contain an isolated finished product is just as simple. The presence of reaction mixtures or waste materials usually will not deter the confirmation of a final product of the operation. Reaction mixtures and waste materials can contain detectable levels of the finished product. The challenge for the chemist is to detect, isolate, and identify the final product in a sample.

At the stage of analyzing waste materials is where the experience and training of the chemist begin to show. There may be only trace levels of a controlled substance. The analytical chemist should be able to recognize the potential final product from the reaction by-products within the mixture. If the proper compound or combination of compounds is present in a mixture, he should devise an analytical scheme that can isolate and confirm the presence of the controlled substance with which they are associated.

Nonoperational labs present a challenge. There are no reaction mixtures or waste products for the analytical chemist to examine. There are no instrumental data on which to hang his opinion and definitively declare the final product of the operation. These situations become mental exercise for the expert. He uses the chemical and equipment information from the scene to identify the most probable product and method used. He evaluates the lists of chemicals that were found at the scene and categorizes them as precursors, reagents, or solvents. He identifies the final products associated with each precursor and the synthesis routes used with each. He then does the same with each reagent chemical. The precursor possibilities are combined with the reagent possibilities, and a hypothesis of the type of operation is derived. To support the hypothesis, the type of equipment is factored into the equation along with any notes, receipts, or additional paperwork with which to complete the puzzle. In Chapter 9, practical applications demonstrate how the chemical inventory can be used to piece together a manufacturing method to answer the question *What is he making?*

Many chemicals can be used to produce more than one controlled substance. Some can be used for more than one synthesis route for the same controlled substance. With hundreds of different synthesis routes for the various controlled substances encountered in a clandestine lab, it is unlikely that the scene or analytical chemist will immediately recognize unfamiliar chemical combinations associated with obscure chemical reactions. He is less likely to put the two together in the chaos of a clandestine lab scene.

Databases containing the chemicals commonly encountered in clandestine labs can statistically narrow the possibilities. If the chemist has access to this type of database, he can cross-reference the chemicals seized with the controlled substance they are associated with as well as the synthesis route. This information will assist him in objectively looking for a pattern that will indicate what controlled substance the operator was trying to produce.

What else is he making? is a corollary question that should be addressed. As a result of this mental exercise, the chemist should be able to determine what other controlled substances could be made with the combination of chemicals seized from the scene. It is not uncommon for the operator to be experimenting with other manufacturing methods. The expert should not lock onto the most obvious final product. He should expand his evaluation to include or exclude all of the possibilities and any *What if?* questions that could be brought up during the peer review process. Many hypotheses fall by the wayside before a theory can emerge.

The expert must remember his limitations. He is an expert in the clandestine manufacture of controlled substances. Unless he has a Ph.D. in chemistry with an emphasis in organic synthesis, he would be well advised not to speculate about any of the compounds that can potentially be produced using a given list of chemicals. The *What if?* questions in this situation can be endless and beyond the expertise of the chemist, as well as the jurors. Just as the forensic drug chemist is an expert in the identification of cannabis but not in plant identification, the clandestine lab chemist is an expert in the clandestine manufacture of controlled substances, not in organic synthesis. Keep it simple when possible.

6.3.3 How Is He Making It?

The simplest method of answering this *How?* question is to ask the operator or look at his notes. Some operators can be talkative. Others are quiet. In all cases, the operator's statements should be put into perspective, because their culture is one of deceit. However, their statements can be used as a guide for the scene investigation and to corroborate opinions generated from the physical evidence.

Clandestine lab operators do not generally have the education or training to cook without a recipe. The paperwork detailing the manufacturing method being utilized is often located somewhere at the scene. This paperwork, combined with the seized chemicals and equipment, demonstrate how the operator was manufacturing his product. However, some operators have committed the process they use to memory, because it is simple, and they have been using it so long. Unfortunately, in these instances, there will be no recipe defining the manufacturing method. Because of this, other forms of corroboration become more important.

The list of chemicals seized from the scene can give insight as to the most likely manufacturing method used. Once the field of possible final products has been narrowed to the most likely candidates, the chemist can compare the list of chemicals required for individual synthesis routes to the chemicals seized from the scene. The synthesis route with the most complete list is the most likely manufacturing method being used. The operator may not have all of the components for the suspected route. However, lack of a complete list of chemicals does not eliminate a synthesis route from consideration. Provided in Chapter 9 are Practical Applications 15 and 16.

As with any opinion, answers to the *How is he making it?* question should only be given after objective review of the physical evidence. However, there are manufacturing methods that are so commonly used and chemical combinations that are encountered so frequently that the on-scene chemist can usually provide a qualified opinion concerning the type of lab and the probable synthesis route. Much beyond that, he is probably treading in water he should not be in, without time to reflect on the totality of the physical evidence. These qualified opinions are necessary to guide the balance of the on-scene investigation. They are used to direct the search for items of physical evidence that will corroborate or supplement the evidence that has been located to that point of time. But, after that, qualified opinions should never be used as defining statements in criminal proceedings. The expert would simply be opening his testimony to cross-examination, if he does not rely on the scientific method to back himself up at all times.

Reaction mixtures and waste materials can provide a wealth of information. Many of these liquids contain all of the information concerning the method used to produce the final product. The precursor and reagent chemical components of a reaction mixture, the reaction by-products in the final product, or waste materials can give information as to the method the operator was using for manufacturing.

The MS provides the clandestine lab chemist a tool with which to identify all of the components within a reaction mixture. Compiled in Appendix K are mass spectral data of reaction by-products that are potentially found in reaction mixtures found in clandestine drug labs. These values are taken from the scientific literature and include the synthesis route associated with each compound. Shown in the table are the compound's five major ions and the synthesis routes with which each compound is associated. The chemist must remember that the ion sequence may differ depending on the instrument he is using. If possible, he should run the actual compound to obtain the actual mass spectrum for identification purposes.

The lack of primary standards for the reaction by-products complicates the identification process. The analytic chemist must rely on the analysis of reaction mixtures he synthesized to obtain the mass spectral data of reaction by-products in various manufacturing methods. He should compare these spectra to the spectra in the literature to confirm the identity of the by-products encountered. Instrumental data from nonprimary standards can be used for these identifications, because the identities of these components do not have to be established beyond a reasonable doubt.

The analytic chemist should attempt to reproduce the manufacturing process used by the operator to demonstrate that it actually works. The recipe being used may or may not produce the intended product. Sometimes the reagents called for will not produce the desired effect. Other times, the operator does not have access to the chemicals listed in the recipe, and his lack of knowledge does not allow him to use the proper substitute. The analytic chemist should go through the steps outlined in the operator's recipe to determine whether or not it would function as designed. Understanding the theory of the reaction is one thing. Having direct knowledge as to whether or not the reaction will produce a controlled substance has greater impact in an opinion. The best way to respond to the question *How do you know the operator's reaction will not produce flubber?* is to respond, "I followed the directions found at the location, using samples of chemicals seized from the location, and the result was flubber."

There will be times when the chemical inventory and the laboratory analysis do not provide sufficient information to determine the synthesis route. These instances require the follow-up question: *Why is he using this method?* This question may be a mental exercise that does not have an answer. When all else fails, ask the operator or look at his notes. His level of cooperation may provide the expert the insight he requires. There will be many instances when the expert has to accept the answer: "I do not know."

6.3.4 How Much ... ?

Depending on the size of the operation, the *How is he making it?* question can take a back seat to the *How much is he making*? question. The fact that the operator was making tetra-ethyl-death by the ABC method, at times, seems secondary to the quantity the operation could produce. The amount of finished product seized or that could be produced may or may not affect the type of charge or the sentence that is handed down if a conviction is obtained. The operation's actual or projected production may have nothing to do with the manufacturing charges. The accused is or is not manufacturing. The fact or opinion that the operation could potentially produce $10,000,000 worth of drugs or enough explosives to blow up the local police station is probably not an element of the crime. However, it may be used as demonstrative evidence to impress upon a jury the size and scope of the operation.

The three basic variations of the *How much*? questions are as follows:

How much product is there?
How much product could the operation produce per batch?
How much product could the operation produce with the existing chemicals?

These questions may or may not come up at trial. However, some variation of each one will be asked of the expert at some point during the investigation or prosecution of the operator. Therefore, the expert should have the answers to each question.

6.3.5 How Much Product?

Of the three basic "how much" questions, *How much product?* is the most relevant. Many controlled substance statutes use a weight value to establish the severity of the offense. The wording of the statute will provide the analytical chemist guidance in developing an analytical scheme with which to address the legal question of *How much is there?* The wording "…grams of substance…" may require a different analytical approach from the wording "…grams of substance containing…" In either case, the analytical chemist should be able to tell how much of the controlled substance in question was in each sample analyzed.

There are two basic methods of determining amount of substance. The direct method is applicable for situations in which the statutes use wording similar to "… substance containing …." The indirect method is applicable to scenarios in which an accurate accounting of the amount of controlled substance is needed.

The direct method is straightforward. The analytical chemist measures the weight or volume of the substance prior to doing any analytical work. This establishes the weight at the time of seizure. For exhibits in which only a sample was received, the accurate documentation of the original weights or volumes is critical. Without documented weights or volumes, the Court will rely on the only documented value available to them, i.e., the weight or volume obtained by the analytical chemist during his analysis.

With the indirect method, a ratio of the calculated concentration of a sample is used to determine the amount of controller substance in the original item. The amount of substance at the time of seizure can be obtained using this calculation. Its use is appropriate when an accurate accounting of the amount of controlled substance is required. The concentration of a sample of the exhibit is determined, and that a ratio of that value is figured into the weight or volume of the original substance. Found in Chapter 9 are examples of how these calculations can be applied.

The resulting value may be subject to interpretation. Issues concerning representative sampling done at the scene, the accuracy and precision of the test methods used to establish the concentration, and the original weight and volume information obtained from the scene will affect the final value.

Proper documentation during every phase of the process is essential. Without supporting documentation, the analysis and the resulting calculations may end up being considered nothing more than speculation and hearsay. If it is not available for peer review, it may not be admissible at trial. However, it may still be useful as an investigative tool.

6.3.6 How Much per Batch?

Determining how much per batch is not a straightforward calculation. There are numerous variables that affect each batch's production. Equipment size, reaction type, recipe, actual versus theoretical yield, and the cook's experience play roles in the operation's per batch production. The expert's training and experience are critical for interpreting the information and factoring in the variables to establish a realistic estimation of the operation's production capabilities.

6.3.6.1 Equipment Limitations

The size of the equipment used in the operation is the major factor that establishes its per batch capability. The operation could have a limitless supply of chemicals, be operated by a Ph.D.-level chemist, and yet still be limited by the size of the reaction flask. A 500 ml reaction flask will only produce a certain quantity of controlled substance during a given reaction cycle.

A simple calculation is used to determine the "per batch" capacity of an operation that utilizes legitimate scientific equipment. As a rule of thumb, the volume of the reaction mixture in a traditional round-bottom reaction flask is two-thirds of its capacity (e.g., a 3000 ml reaction flask has approximately 2000 ml of usable volume). This allows for uniform heat distribution and safe and efficient reflux or distillation. However, because of the operator's lack of technical expertise, the flask may be filled to the top or only 25% of the flask's capacity may be used.

The operator's use of alternative equipment also negates any assumption of proper proportions. There is no rhyme or reason as to why or how full the makeshift reaction vessel is filled. In these situations, as well as the situation in which legitimate scientific equipment is used, the expert should rely on the operator's notes to provide guidance as to the per batch production, because operators do not usually deviate from their recipes.

Once the volume of the equipment has been determined, the ratio of chemicals used in the method is factored into the equation. Using the two-thirds capacity guideline, the reaction mixture maximum volume is established. The analytic chemist calculates the amount of precursor and reagent chemicals required to establish that volume. The calculated precursor amount is then used to calculate the amount of product that will be produced with this amount of precursor chemical. Presented in Chapter 9 is an example of how this calculation can be applied.

6.3.6.2 Chemical Limitations

The amount of precursor and reagent chemicals available can limit the per batch amounts. The operator cannot produce more product than the precursor chemicals he starts with allow, no matter what the reaction vessel size. By the same token, the amount of reagent chemicals present will limit the amount of precursor chemical that can be converted into the final product. These values have more relevance in the estimates of the operation's total production capability.

6.3.6.3 Reaction Limitations

In calculating product yields, the expert must decide what value he wants to demonstrate — the actual or the theoretical. The maximum yield of a chemical reaction is theoretically 100% conversion of precursor to product, i.e., 1 mole of precursor chemical will produce 1 mole of product. The actual yield will always be less than the theoretical yield. This number will vary with the reaction, the recipe, and the experience of the operator.

The expert must take into account the difference in molecular weight between the precursor chemical and the final product. The molecular weight of a substance is simply the weight of a single molecule of the substance. The ratio of the molecular weight of the final product and the precursor chemical involved provides a conversion factor that can be used to calculate the amount. In Appendix N, the conversion factors for commonly encountered controlled substances and their associated precursor chemicals are listed. The conversion factor can be used to quickly calculate the weight of a final product from a known weight of precursor chemical, assuming 100% conversion. Practical examples of how to apply these principles are presented in Chapter 9.

The manufacturing methods used in clandestine labs are based on reactions that have been published in the scientific literature. These publications generally report the theoretical and actual yields for the reactions on which they are reporting. Some reactions are efficient and will produce actual yields that approach 90%. The yields of other reactions are substantially less. The expert must remember that the published yields may not correspond to those of clandestine operations. The published yields are obtained under ideal conditions, and the conditions of the operation under investigation are usually less than ideal.

The expert should rely upon the percentage yield of the reaction when estimating the amount of final product a given amount of precursor chemical would produce. These opinions should address three situations. First, the perfect situation in which 100% of the precursor is converted into the final product should be addressed. Second, what the literature states the expected yield should be if the reaction were done under controlled laboratory conditions should be considered. Finally, what the yield in a clandestine lab situation would be should be addressed. The analytical chemist who performs the reaction, mimicking the operating conditions of the lab operation under investigation, can obtain the actual yield value. The analytical chemist may compare his values to those of the operator who may have calculated production yields.

The only value the expert can produce with any degree of certainty is the 100% conversion value. This hard value is based upon the molar conversion of a specific amount of precursor to a specific amount of final product, taking into account the differences in molecular weights. The published yield values were obtained under controlled conditions that, as a rule, will not be experienced in a clandestine operation. Thus, those values can only be used as a guide to estimate the production of a given amount of precursor chemical. The yield obtained by the analytical chemist when validating the method under investigation can be used to approximate the operation's yield. However, he should factor in his laboratory technique, the elimination of variables introduced into the operation because of the operator's experience and training, and the "lab" conditions of the operations.

When discussing the yield of an operation, the expert's opinion should simply state that a given amount of precursor chemical would theoretically produce a given amount of final product. He should be willing to acknowledge that the actual value will be lower because of the variables involved in the production of the product. He should also be prepared to describe how he arrived at the lower figures, by the use of published data, of his own analytical experiments, through the use of notes from the operator, or by a combination thereof. Being able to defend his opinion in a calm and organized fashion is crucial to his perceived reliability.

Multistep reactions place additional variables into the equation that should be accounted for. Each step of the manufacturing sequence has a characteristic yield that may or may not be the same as the previous step. In calculating the total production from a given operation, the expert needs to account for the yield estimates for each individual step in the sequence and be able to describe the differences and why they exist, if necessary.

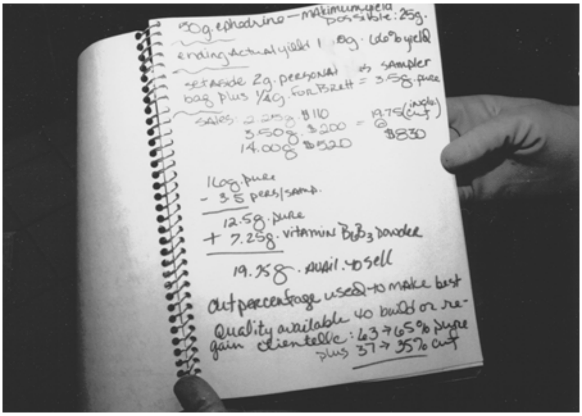

Figure 6.3 Handwritten notes.

6.3.7 How Much per Week?

There are a number of variables that affect an operation's production over a period of time. The synthesis route, the number of batches in the time frame, the cook's experience, and the availability of chemicals will affect this value. Even with these unknowns, there is information available that can be used to produce a historical perspective of the operation's production.

The seized paperwork is the best source of information concerning overall production. The relevant paperwork that can be used to establish production amounts includes sales ledgers, production logs, chemical receipts, and recipes. Such information is generally available at the scene, again because of the typical operator's pack rat nature. Receipts provide a purchasing pattern of the required precursor chemicals. Per batch and per week estimates can be extrapolated from these receipts and other information from the scene to obtain a historical production pattern or to project one into the future.

Some operators do the work for the expert. They have been known to document the per batch production, some to the extent of even calculating yield percentages (Figure 6.3). Other paperwork found at the scene may document sales or distribution information. If the documents contain dates associated with amounts, a historical portrait of the operation may be obtained. The key to using this type of information is the ability to decipher the operator's shorthand or codes. This situation is an example of where the expert's knowledge of clandestine operations is essential. His ability to translate cryptic notes into understandable language assists investigators and attorneys involved in the case by providing a better understanding of the various portions of the operation to which the notes refer.

The operator's recipes can also be extrapolated to provide a historical representation of the operation's production. However, in doing so, a number of assumptions must be made. Operators do not tend to deviate from the recipes they use. Therefore, per batch estimates can be calculated; the amount of precursor chemical denoted can be used to estimate a time frame for their consumption. Any estimates beyond that will be considered speculation on the expert's part without additional information.

Assumptions come into play in this situation, and the numerous *What if?* questions can be asked. The expert can calculate the single-batch production using the techniques listed above. The number of batches per day, per week, per …, is subject to conjecture without additional information. These estimates can be made, but the variables used to provide the opinion should be made up front. For example, at 100% conversion, 1000 g of ephedrine hydrochloride will produce 920 g of methamphetamine hydrochloride. It is misleading for the expert to claim that the whole 920 g could be produced at once if the operator's recipe called for 10 g of ephedrine. All of the variables must be reasonably addressed. With the per batch information factored into the opinion, it would take 100 batches to convert all 1000 g of ephedrine into methamphetamine. More information is needed to determine how long that would take, or another assumption would have to be made and presented to qualify the opinion.

It is in the best interest of the expert to be candid about the information used to produce his opinion. Playing word or number games in trial or deposition can compromise the expert's credibility or diminish his objectivity in the eyes of the jury. He must remember that his role is to provide the information needed for jury members to make informed decisions. Providing information concerning the assumptions used to make the opinion will reduce the *What if?* questions that can be posed by either counsel. Using the previous example, the expert would be wise to say that, assuming 100% conversion, the operation could theoretically produce 920 g of methamphetamine in 100, 10-g batches.

If more detail is requested, more information is required, or more assumptions must be made. *How long does a single batch take?* and *How long between batches?* are not unreasonable questions. Their answers will affect the span of time necessary to convert the entire amount of known precursor into the finished product. The expert should not render an opinion concerning production time frames without qualifying his response by establishing the parameters that frame it.

6.3.7.1 Production with Available Chemicals

How much controlled substance could the operation produce at the time it was seized? This question can be answered by using the chemicals that the suspect had on hand to estimate the amount of product that could be produced. To provide a total picture of the operation's production potential, the expert will need to calculate the amounts using the most-abundant and least-abundant chemicals. The most-abundant chemical calculation will provide information concerning the operation's potential, if the balance of the necessary chemicals is obtained. The least-abundant chemical provides information concerning the limitations on the amount of product the operation could produce at the time the operation was seized. The focus should still be the operation's potential product. The time requirement does not enter into these calculations. Obviously, depending on whether the expert is testifying for the prosecution or for the defense, there will be differing emphasis placed on cross-examination. It is always better to have all of the information, either way.

These calculations differ slightly from the "per week" estimates in that the expert takes into account the amount of reagent chemicals required. If the operator does not have the necessary reagent chemicals, the reaction cannot take place. For example, the amount of methamphetamine that can be produced from the 1000 g of ephedrine from the previous section is zero if there are no reagent chemicals to facilitate the conversion. That is not to say that a clandestine lab does not exist. It only means that at the time of the seizure, the operation could not produce methamphetamine.

In establishing the chemical ratios required for these calculations, the expert should rely on the operator's notes or recipes. These will provide the most accurate information concerning the operation's production methods, which is used to estimate the operation's production potentials. Not having access to this information, the expert should fall back on ratios from clandestine operations using similar manufacturing techniques. If these sources are unavailable to the expert, the scientific literature should be consulted.

The expert should provide the 100% conversion value as well as an adjusted yield value using available percentage yield values. If these are unavailable, he should stick to the 100% yield value, acknowledging the fact that the actual value will be lower. As with all production estimates, the expert needs to acknowledge that the actual production will be less than the total conversion value.

6.4 Summary

The clandestine lab investigator must answer the *Who? What? When? Where? Why?* and *How?* questions concerning the operation. The forensic clandestine lab investigator will be most concerned with specific questions of *What? Where?* and *How?*

- The following are important *What?* questions:
  - What were they making?

    - What chemicals and equipment were used in the operation?
    - What production methods were used?
- The following are important *Where?* questions:
    - Where was the lab located?
    - Where were specific parts of the lab located?
    - Where was the finished product or waste material located?
- The following are important *How?* questions:
    - How was the operator making the controlled substance?
    - How much finished controlled substance was there?
    - How much finished controlled substance could the operator make?

To answer these questions, the expert requires information from a variety of sources in order to form a strong objective opinion. The information can come from the scene of the operation, from the laboratory analysis of samples taken from the scene, or from the expert's specialized training and experience in the area of the clandestine manufacture of controlled substances. The information from three sources is combined to formulate the total picture of the clandestine operation.

Information to answer the *What is he making?* question can be obtained from the seized notes and recipes, the lab operator, the laboratory analysis of samples from the scene, or the chemical inventories. Information to answer the *How is he making it?* question can be obtained from seized notes and recipes, the chemical inventory, the equipment inventory, or the laboratory analysis of samples from the scene. Finally, information to answer the *How much…?* questions can be obtained from the seized notes and recipes, the laboratory analysis of samples from the scene, or the chemical inventories.

The opinions provided concerning the existence of a clandestine lab should be neutral and based upon the known facts. As with all forensic evidence, it should be presented in an objective fashion that allows the judge or jury to make an informed decision based on objective information.

The expert opinions provided in the investigations and prosecutions of clandestine labs are key to determining the direction of the investigation or the subsequent trial. The expert can imply whatever he deems reasonable, i.e., that the operation was the largest ever seized. He may, on the other hand, reduce the significance of the same set of facts to diminish the seizure to an insignificant occurrence.

The forensic expert must remember that his purpose is to evaluate the evidence in an objective manner and provide his opinions in an understandable fashion. He is not in Court to establish guilt or innocence. The purpose of an expert opinion is to assist those charged with establishing guilt or innocence by providing the information they require to make an informed decision.