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Chapter 16 Document and Handwriting Analysis

Objectives

After reading this chapter, you will understand:

- That an expert analyst can individualize handwriting to a particular person.
- What types of evidence are submitted to the document analyst.
- Three types of forgery.
- How to characterize different types of paper.
- The types and impact of computer crime.

You will be able to:

- Characterize your own handwriting using 12 points of analysis.
- Detect deliberately disguised handwriting.
- Detect erasures and develop impression writing.
- Design an experiment using paper chromatography to determine which pen altered a note.
- List safeguards against the counterfeiting of U.S. currency.
- Recognize some of the methods of Internet fraud.
- Identify questions and concepts that guide scientific investigations.
- Communicate and defend a scientific argument.

"The handwriting on the wall may be a forgery."

—Ralph Hodgson, British poet

Documents as Evidence

The examination of questioned documents covers many areas of investigation, including verifying handwriting and signatures; authenticating documents; characterizing papers, pigments, and inks used in writing instruments and copying machines; restoring erased and obliterated writing; and even determining the relative age of documents and inks.

Forgery has been practiced since the beginning of writing. Under Roman law, the Code of Justinian enacted in AD 539 stated that handwriting should be compared in the case of public documents and private instruments where an advantage could be gained. The code ordered that experts be used.

Why would anyone be concerned about a piece of paper? Believe it or not, paper is involved in most crimes—perhaps directly, as with a ransom note in a kidnapping or a forged signature on a check; perhaps indirectly, as with business records in a drug operation or a receipt for a car rental.

The document examiner's tools are the stereomicroscope, templates, protractors, grids, and other measurement devices. The examiner may use different types of light sources to detect forgeries, changes, and obliterations.

class characteristics: like class evidence, features that are typical of a group. The more different class characteristics there are with the subject of attention, the more the size of the group can be reduced until, ultimately, it is a group of one. It is then unique.

Handwriting's individuality makes this type of physical evidence, like fingerprints, one of the few definitive tools available to the investigator. When we are young, most of us learn how to write in a fairly consistent manner by copying examples of letters and words, so at first our writing looks much like everyone else's. Many of these common writing habits carry over to our adult years and are called **class characteristics**. However, over the years, our knowledge of

Even though we all learn to write the same way, we develop individual characteristics with experience.

how to write becomes somewhat subconscious, and we each develop different nuances in our writing. The combinations of such unique features give our handwriting **individual characteristics** that differentiate one person's writing from another's. The way we write becomes so embedded in our subconscious that it is actually quite difficult to disguise. Given enough evidence and *exemplars*, a document expert may be able to present handwriting as individual evidence in a court of law (see Figure 16.1 on page 487).

individual characteristics: like individual evidence, qualities that cause the subject to be unique.

Reminder

exemplar: a known sample that is used for comparison; also referred to as a *specimen*

Analysis of Handwriting and Handprinting

Handwriting experts may be able to make a positive identification if there are enough samples for examination and enough exemplars against which to compare those samples.

To determine whether a signature or writing sample is authentic, a document examiner will generally examine 12 characteristics:

1. *Line quality:* Are the lines smooth, free-flowing, and rhythmic, or shaky, nervous, and wavering?
2. *Spacing of words and letters:* Examine the average amount of space between words and letters. Is the spacing consistent in the questioned and known documents?
3. *Ratio of relative height, width, and size of letters:* What are the overall height, width, and size of the letters in both the known and questioned documents? Are they consistent?
4. *Pen lifts and separations:* Check how the writer stops to form new letters and begin words. Forgeries may have pen lifts or separations in unusual places, for instance within a single letter.
5. *Connecting strokes:* Compare how capital letters are connected to lowercase letters and how strokes connect between letters and between words.
6. *Beginning and ending strokes:* Compare how the writer begins and ends a word, number, or letter.

The Dreyfus Affair

During the Franco-Prussian War, the Germans routinely obtained French military secrets. A French spy working as a cleaning woman in the German embassy found a handwritten letter in a wastebasket referring to the sale of military secrets. Captain Alfred Dreyfus was convicted of treason based on the erroneous identification of handwriting samples by our old friend, Bertillon, then a junior records clerk in the Sûreté. In 1894 Dreyfus was sentenced to life imprisonment on the notorious Devil's Island in French Guiana. Four years later, the famous French author Émile Zola publicly condemned the court martial, eventually leading to Dreyfus's exoneration and return to society and the army.

A handwritten letter showing individual characteristics

Are the strokes straight, curled, long, or short? Are they made on the upstroke or downstroke?

7. *Unusual letter formation:* Look for unusual letter formation; for instance, letters written backward, letters with a tail, or unusual capitals.
8. *Shading or pen pressure:* Individuals use different amounts of pressure with a pen or pencil, making the lines lighter or darker, narrower or wider. Check for pressure on the downward and upward strokes.
9. *Slant:* Does the writing slant to the left or right, or is it straight up and down? Are some letters consistently slanted more or less than others?
10. *Baseline habits:* Does the writing tend to follow a straight horizontal line, or move downward or upward? Is it above or below the baseline?
11. *Flourishes or embellishments:* Are there any fancy letters, curls, loops, circles, double loops, or underlines?
12. *Placement of* ***diacritics****:* Check the crossing of *t*'s and dotting of *i*'s, *j*'s, or any other letters or punctuation marks. Is the cross on the *t* long in proportion to the stem? Is it located to the left or right of the stem? Are the *i*'s dotted above or to the right or left of the stem?

diacritics: the crossing of *t*'s or dotting of *i*'s and *j*'s

The examiner also looks for irregularities such as an awkward or unnatural appearance or circle shapes made up of different strokes. There is wide variation in how people make their uppercase (capital) letters and the lowercase letters *y, j, g,* and *q*.

Analyze Your Own Handwriting — Activity 16.1

Get a long piece of your own writing or copy three to four paragraphs from this book. Use the criteria described above to comment on each of the 12 characteristics:

1. Line quality
2. Spacing of words and letters
3. Ratio of relative height, width, and size of letters
4. Pen lifts and separations
5. Connecting strokes
6. Beginning and ending strokes
7. Unusual letter formation
8. Shading or pen pressure
9. Slant
10. Baseline habits
11. Flourishes or embellishments
12. Placement of diacritics

Does handwriting reveal your personality? No. This type of analysis is called *graphology* and is junk science. Handwriting also cannot be related to sex, race, education, or religion, and usually not to health or age. A linguist, however, can often postulate the type of person and his or her background based on a writing sample. One example of this happened in the Lindbergh kidnapping case.

16.1: Anonymous Writing

CASE STUDY

In the case described below, comments were added to a document. Were they written by the same person who wrote the body of the document? The questioned document is a photocopy of a government form. K1 refers to the known writing, and Q1, Q2, and Q3 are the questioned writing.

The following has been taken almost verbatim from http://qdewill.com, with permission of Emily J. Will, forensic document examiner.

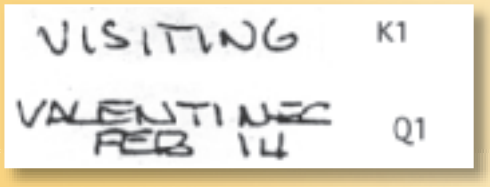
Procedures and Observations: All of the writing in this case was examined with the unaided eye and under a microscope at magnifications from 7 × 25. Glass alignment plates were used to examine the baseline, top line, and spacing of the writing. The following writing characteristics were apparent:

1. Both known and questioned writings use entirely uppercase letters, with the possible exception of the "I" which may not always be in the form of

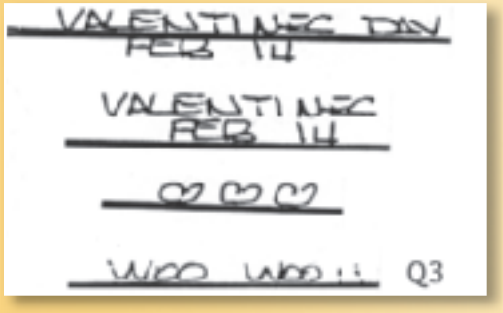
the capital. Although there is no dot over the "I" to indicate a lowercase letter, the simple "stick" form of the "I" is used and it varies in height.

CASE STUDY CONTINUED

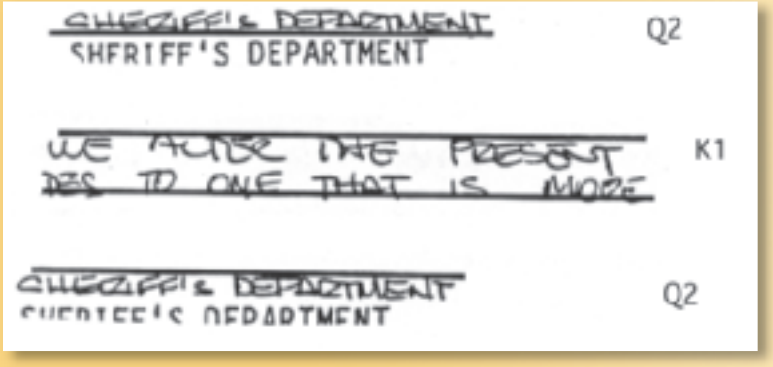
2. Letterspacing resembles that of elite or pica type in that it is nonproportional (every letter is given almost the same amount of horizontal space, regardless of how much space it requires). The result is open space around the "I" of "Valentines" and, to a lesser extent, the "I" of "Sherriff's" in Q1 and Q2.



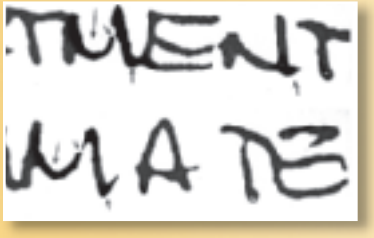
3. The baseline of Q1, Q2, and Q3 is artificially straight and appears to have been formed by holding a straightedge on the paper as a guide. Possibly this was done as a disguise factor. The bottoms of the letters "D," "B," "O," and others are complete, although flattened. Therefore, the straightness of the baseline is not due to the bottom of the writing being clipped off with scissors in a cut-and-paste maneuver. The baseline of K1 is basically straight, although lacking in the precision shown in Q1–Q3. In the illustration a glass plate containing an etched line has been placed on top of the questioned document and photographed to point out the straightness of the baseline and the flattened bottoms of the letters.



4. The top lines are also quite straight, but are formed naturally by letters that are consistent in height. This is true in K1 and in Q1–Q3. This exhibit shows top and bottom line straightness in K1 and Q2.



5. There is a small stroke toward the right at the end of many downward vertical strokes of letters such as "M," "N," "P," "T," and "H." This is obvious in the knowns, and even though Q1–Q3 may have been formed against an artificial baseline, these strokes are evident in the "1" of "14" in Q1 and in the "P" and "M" of Q2. Notice this small stroke on the "M"s shown here. The top line is from Q2 and the bottom is from K.

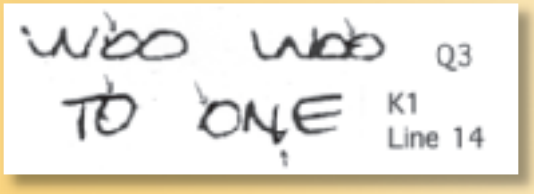


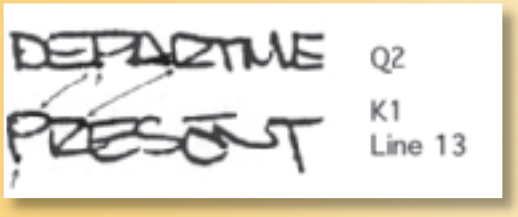
The "M"s show further evidence of identity in the shape and movement of the center curved stroke and the small hitch in the line which occurs in the same place in each writing. As further

illustration of this characteristic, the known and questioned writing have been optically overlaid and photographed through a comparison microscope. Color is achieved by using filters on the microscope's illuminators. The red is the questioned writing, the green is the known, and the black is where the two overlap.

CASE STUDY CONTINUED

6. The "O"s often join at the 9 or 10 o'clock position in both the known and questioned writings. Notice this with the words "woo woo" in Q3.
7. The crossbar of the "A" and the "buckle" of the "R" are positioned close to the baseline (see Q2).
8. Although the writing is hand-printed, there are connections from letter to letter and places where adjacent letters touch. This is a characteristic which could be more closely examined on the original document, but it is clear enough from the copy that this characteristic exists in both the known and questioned writing.





Conclusions: After a thorough examination of the questioned document, it is the examiner's opinion that the known writing (K1) and the questioned writing (Q1, Q2, and Q3) were written by the same person. All that remains is to produce the original to ascertain that the questioned material was actually written on that document, and not placed there mechanically.

This case illustrates the principles learned in Activity 16.1, but more importantly, how and to what extent the forensic document examiner carried out the analysis.

Methods of Forgery

The most common **forgery** is a signature. There are three types of forgery.

One of the most common types, and probably the easiest to detect for a layperson, is a **blind forgery**, where the forger uses his or her own handwriting. The forger does not even try to copy the original signature, and may not even know what the signature looks like. This is usually the case in petition fraud and anonymous harassing subscriptions, as well as in many other civil and criminal cases. Investigators have the highest success rate in identifying this type of forger.

forgery: an item prepared with the intent to deceive or defraud. It can be an autograph, a book, a painting, a baseball card, a stamp, an antique, or almost anything.

blind forgery: one made without a model of the signature or writing being forged

simulated forgery: one made by copying a genuine signature

traced forgery: one made by tracing a genuine signature

Copying a genuine signature by carefully drawing it is termed a **simulated forgery**. Often the forger practices the signature so much that he or she can avoid many of the hesitations and pen lifts usually seen in a forgery. Investigators can detect a simulated forgery by identifying the individual microscopic handwriting traits consistently present in the known signatures but missing from the questioned signature. The forger is often unable to duplicate *all* the victim's individual handwriting habits. This type of forgery can be very difficult to link to a suspect.

A third type of forgery is a **traced forgery**, which can be done by tracing a genuine signature onto a document using a light box or similar device. Forgers may use other methods such as carbon paper or even pressing hard over a genuine signature and then tracing the indentation. Stereomicroscopic examination can disclose this type of forgery, because the line quality may be inconsistent. Sometimes oblique lighting will show off the indentations.

Activity 16.2 Simulated Forgery

Use the handout provided by your teacher for the following exercise.

A. Write your name (signature).
B. Write your name again.
C. (Leave blank.)
D. (Leave blank.)
E. Have someone copy your signature (after practicing on scrap paper).
F. Have someone else copy your signature (after practicing on scrap paper).

G. Disguise your signature.

H. Write "cleopatra." (Note: example shows eighteen.)

I. Have the same person who copied your signature for item E copy this.

J. Write "cleopatra," but disguise your handwriting.

K. Write "ninety-six."

L. Have the same person who copied your signature for item F copy this.

M. Write "ninety-six," but disguise your handwriting.

N. Write the numerals 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9.

O. Have the same person who copied your signature for item E copy the numerals.

P. Have the same person who copied your signature for item F copy the numerals.

Q. Write the numerals in disguised writing. (Note: this is "R" in example on next page.)

R. Go back to items C and D and write your signature again. Examine your four signatures and note any differences. Look at the 12 characteristics listed and describe the differences based on these.

S. Note similarities between your normal handwriting and your disguised handwriting in items G, J, M, and R. Normally you alter the major characteristics of your handwriting, but the minor ones give you away. What major characteristics from the 12 points did you change? What minor ones remain?

T. Examine some of the signatures made by your classmates in items E, F, L, I, O, and P. Comment on some of the primary signs of forgery, such as which ones have:

- **a.** the appearance of being written slowly.
- **b.** blunt line endings and beginnings.
- **c.** poor line quality, with wavering and tremors of the line.
- **d.** retracing and patching.
- **e.** stops in places where writing should be free and smooth.
- **f.** inconsistent letter formation.

HANDWRITING EXERCISE

A.		write your name (signature)
B.		do it again
C.		leave this blank for now
D.		ditto
E.		have someone copy your signature
F.		have someone else copy your signature
G.		disguise your signature
H.	eighteen	write "eighteen"
I.		have E copy this
J.	eighteen	write "eighteen", but disguise your handwriting
K.	ninety-six	write "ninety-six"
L.		have F copy this
M.	ninety six	write "ninety-six", but disguise your handwriting
N.	0123456789	write the numerals 0 through 9
O.		have E copy them
P.		have F copy them
R.	0123456789	you write them with disguised writing

1. Now go back to C and D and write your signature again. Examine your four signatures and note any differences. Look for the 12 basic characteristics that are described in Table 1.

Activity 16.3 Blind, Simulated, and Traced Forgery

Plagiarism is a form of forgery and, as such, is illegal.

Materials

- light box (or windowpane)

For each group:

- carbon paper
- pad of paper
- tracing paper

Procedure

1. Use the three methods described on page 484 to forge person E's signature from Activity 16.2.
2. Examine your results.

3. Attach your samples in your notebook.

What would a document examiner look for in these signatures if he or she suspected fraud? Which method worked best for you? Comment.

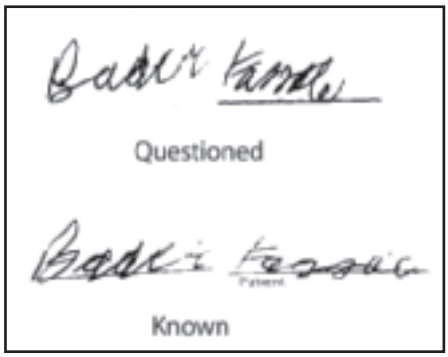


Figure 16.1 Forged signature

Analysis of Handwriting Using a Letter Angle Template

Activity 16.4

Investigators use the letter angle template to determine the slant of individual letters, groups of letters, words, or sentences (characteristic 9 from the list on page 480). The plate you will be using is designed for better visibility and more accuracy than would be possible with the use of an ordinary protractor.

There are three number scales on the upper part of the plate. The first two scales, #1 and #2, are for letters or writing that slant to the right of vertical (the degree line marked "0°"). The third scale, #3, is for letters or writing that slant to the left of vertical. Scale #1 is graduated from 0° to 30° to the right of vertical. Scale #2 is graduated from 30° to 60° to the right of vertical. Handwriting that slants more than 60° is comparatively rare. Scale #3 is graduated from 0° to 30° to the left of vertical and is used for so-called **backhand writing**.

backhand writing: writing in which the slant of the letters is to the left of vertical

Materials

For each group:

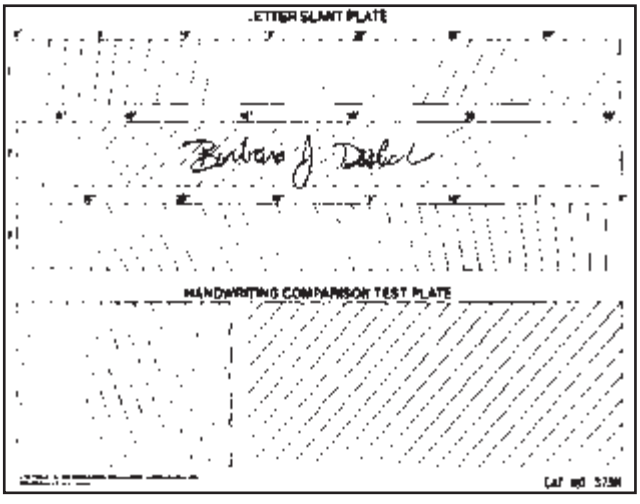
- letter angle template
- paper
- writing instrument (pen or pencil)

Procedure

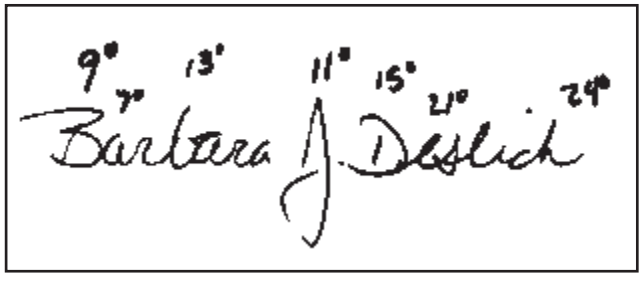
1. Write your signature four times in your notebook.
2. To use the letter angle template, put the transparency over the first individual letter in signature 1. Move the scale from right to left until you can center your letter in one of the boxes. Read the scale above the box that best parallels your letter. Write the degree reading above the letter. Move the template to the next letter and measure the slant degree. Write the degree reading above the letter. Continue until you have measured all letters in all four of your signatures.

Analysis Questions

1. Do the angles match on all of your letters?
2. Give the range of degrees within which your slant varies.
3. Is the angle of the first letter of your last name the same for all four signatures?
4. Do any of the letters have the same angle in all four signatures? Which ones?
5. Use the letter angle template to compare the same word you have written in three different places in your notebook. Label the angles of the letters above each letter in the word. Write down the page numbers of the samples.
6. How did the three compare? What is the range of angles in your three words?
7. Would this be a good basis of comparison to analyze your handwriting? Comment.



An example of using the letter slant plate to determine the angles in the letters of a signature



Signature with letter angles labeled

Analysis of the Tops and Bottoms of Letters

Activity 16.5

Normally your signature varies slightly from signature to signature. If two signatures can be measured to be exactly the same in every way, it may indicate that someone forged the signature by copying or tracing. You may see, however, a consistent pattern to your signature writing.

Materials

For each student:
- tracing paper
- ruler
- paper
- writing instrument (pen or pencil)

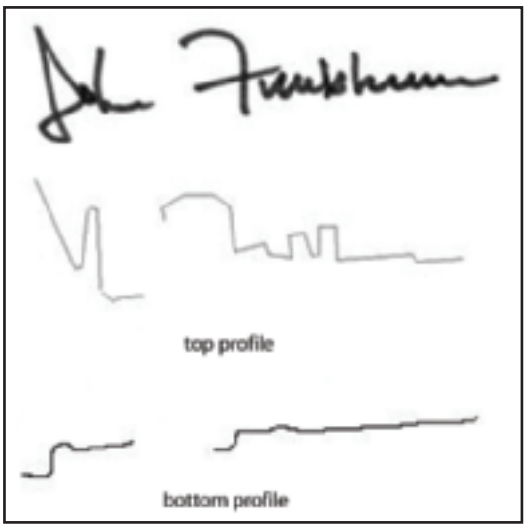
Procedure

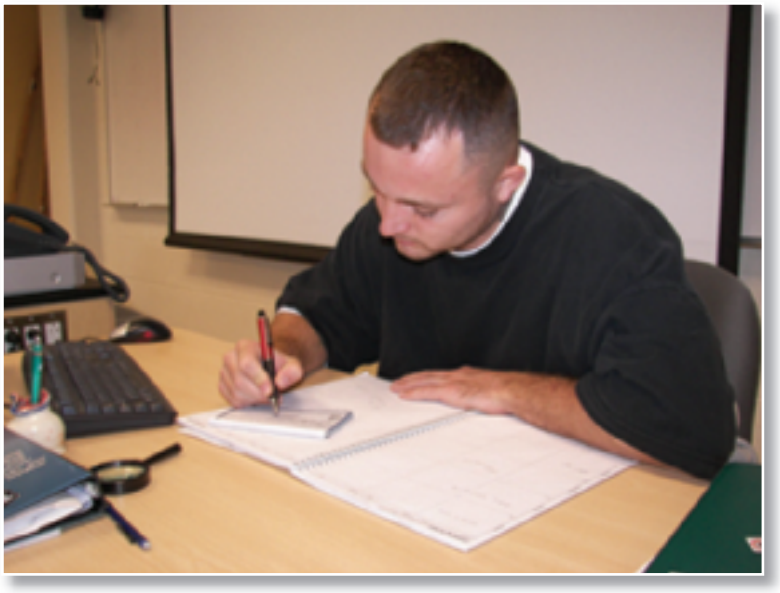
Part 1: Top of the Letter

1. Begin your analysis by writing your signature four times.
2. Place a piece of tracing paper over your signature. Make a small mark on the paper at all of the high points of each letter in each signature. For example, the letter *M* has three points: one above the first vertical line, one above the first hump, and one above the second hump.
3. Using a ruler, join each mark to the one next to it, creating a zigzag line across the top of each signature. Compare the zigzag lines from the different signatures. Note the similarities and differences.

Part 2: Bottom of the Letter

1. Using the same four signatures, make a small mark on the tracing paper at all of the low points of each letter in each signature.
2. Using a ruler, join each mark to the one next to it, creating a zigzag line across the bottom of each signature.
3. Compare the zigzag lines. Comment on the similarities and differences.
4. Attach the tracing paper in your notebook.





Analyzing handwriting samples

Activity 16.6 Detecting Deliberately Disguised Handwriting

While it isn't easy to disguise your writing in a short sample, it becomes more and more difficult as you continue to write a longer piece. Authorities may ask an individual for a sample of writing that is several pages long. Not only can handwriting be compared, but margins, the arrangement of the writing on the paper, alignment, punctuation, spelling, and grammar may also be individualized.

Materials

For each student:
- **paper**
- **writing instrument (pen or pencil)**

Procedure

1. **Write the following paragraph on a clean sheet of paper using your everyday handwriting. Include your name on this piece of paper.**

   If you ever want to see your dog again, read carefully. Do not call the authorities; do not notify any of your neighbors. Yes, we have your precious Buddy. He is a fine example of an American pit bull, is well trained, and I'm sure will bring a nice price. If you want to see Buddy safe and alive again, you will need to bring $3,500.00 in unmarked bills to

locker #48B at the bus terminal. Put the money in a plain paper bag and put it in the locker by 7:30 PM on Monday. We will be watching you to make sure you drop off the money and leave. Call the following phone number to receive further instructions: 555-6789. If all goes well, you will get Buddy back; otherwise you will never see him again.

2. On the bottom half of the page, write the paragraph again, doing your best to disguise your writing. If you wrote in cursive on the top, make sure you write in cursive on the bottom. If you used your right hand on top, use your right hand on the bottom. Do *not* write your name on the disguised piece.
3. Your task is to match each of the disguised writings with the source of the original writings.

Obliterations

Often documents are changed after they are prepared. Common methods include physically erasing with a rubber eraser or scraping the ink off the paper's surface. Both methods disturb the upper layer of fibers or the paper's coating; you can see these disturbances under the microscope in reflected oblique lighting. Many papers today are coated with optical brighteners that make the paper look very white when seen under UV light. Disturbing the coating may cause a darker area to appear.

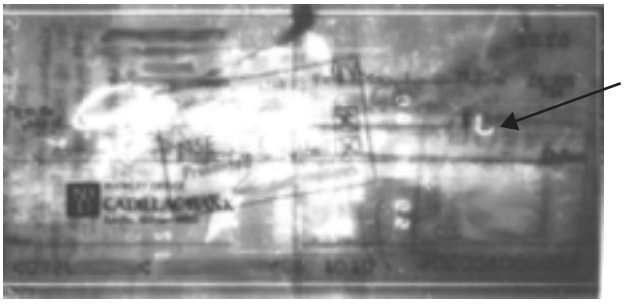
obliterate: to remove writing

Forgers also use chemical methods to **obliterate** words. For example, a strong oxidizing agent such as chlorine or sodium hypochlorite can make ink become colorless. Examining the sample under a microscope or in UV or infrared (IR) light may reveal the alteration (see the checks in Figure 16.2).

Indeed, use of alternate sources of lighting, that is, lamps or lasers with specific wavelengths, can be a powerful way to show the differences among inks of the same color but with different composition. Investigators have successfully used infrared photography to find erasures, read content

check as tendered

check as written



check under infrared lighting

Figure 16.2 Alteration of a personal check

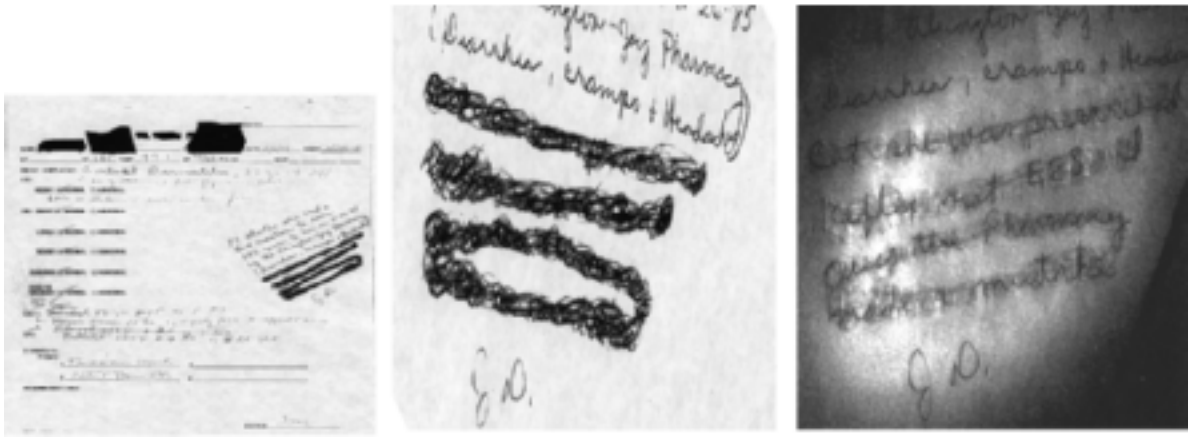


Figure 16.3 Medical records fraud case. The notation on the file copy was partially obliterated, but underwriting became visible under infrared lighting.

covered by intentional obliterations (crossing out), and even reconstruct writing from charred documents (see Figure 16.3).

Digital image processing is becoming a more useful tool in making obliterated markings more visible through lightening, darkening, contrast, and filters.

Finding Erasures

Laboratory Activity 16.1

This activity will give you practice in reconstructing obliterated writing.

Materials

For each group:

- different types of paper
- pencil
- eraser
- UV light
- iodine crystals
- beaker with cover
- camera

SAFETY ALERT! CHEMICALS USED

Always wear goggles and an apron when working in the labaratory

SAFETY NOTE *Also wear disposable laboratory gloves. Avoid inhalation, ingestion, or skin contact with chemicals.*

Caution: *Do not look directly at UV light. Doing so can damage the eyes.*

Procedure

1. Write your signature or some numbers in pencil on several different papers. Erase the writing.
2. Examine the erasures in a darkened area with a UV light. Can you see where you erased your writing? Record your observations for each type of paper.
3. Put the papers in a beaker with a few crystals of iodine, as you did in developing fingerprints on paper in Chapter 4. Cover the beaker, wait a few minutes, and note any evidence of erasures. Record your observations for each type of paper.

Indentations

Often an indented impression is left on paper beneath the primary writing because of the pressure of the writing utensil. These impressions can sometimes be used to forge a signature, but often they have also led to the arrest of criminals. The method we have all seen of rubbing the impression with a soft pencil is the worst thing to do. It doesn't work very well and alters the evidence. Often, oblique lighting will enhance the indentations.

Indentations also increase a paper's capacity to hold an electrostatic charge. This property is used to "develop" images using an electrostatic detection apparatus (ESDA). Pouring toner powder from a copy machine over a charged sheet of plastic covering the paper in question can create an image of the impressions, which is then photographed.

Operating an ESDA

Enhancing Indented Writing

Laboratory Activity 16.2

Through this activity, you will gain practice in visualizing primary writing by using the impressions left as **indented writing**.

indented writing: impressions left under paper that has been written on

Materials

For each lab group:

- paper
- ballpoint pen
- flashlight
- iodine crystals
- beaker with cover
- camera

SAFETY ALERT! CHEMICALS USED

Always wear goggles and an apron when working in the labaratory

SAFETY NOTE *Also wear disposable laboratory gloves. Avoid inhalation, ingestion, or skin contact with chemicals.*

Procedure

1. Write a short note on the top piece of paper overlying at least two or three others.
2. Separate the sheets of paper and view each one with oblique lighting. How many pages can you interpret? Record your observations for each paper.
3. Cut the pages and put them into the beaker with the iodine.
4. Observe any development and photograph. Record your observations for each paper.

Individualizing Typing and Printing

When typewriters were commonly used, investigators could often individualize their printing by examining wear and defects in the typeface and misalignment of characters. The FBI maintains a library of makes and models of all manufactured typewriters as well as thousands of type fonts.

Close-up showing letters and numbers on a typewriter

Word processors and printers have largely replaced typewriters, yet there are still ways to trace and compare output. For example, color printers and photocopiers may add a pattern of minuscule yellow dots to the printout, encoding the printer's serial number.

The *Haas Atlas* is a compilation of about 4,000 typefaces cataloged by font.

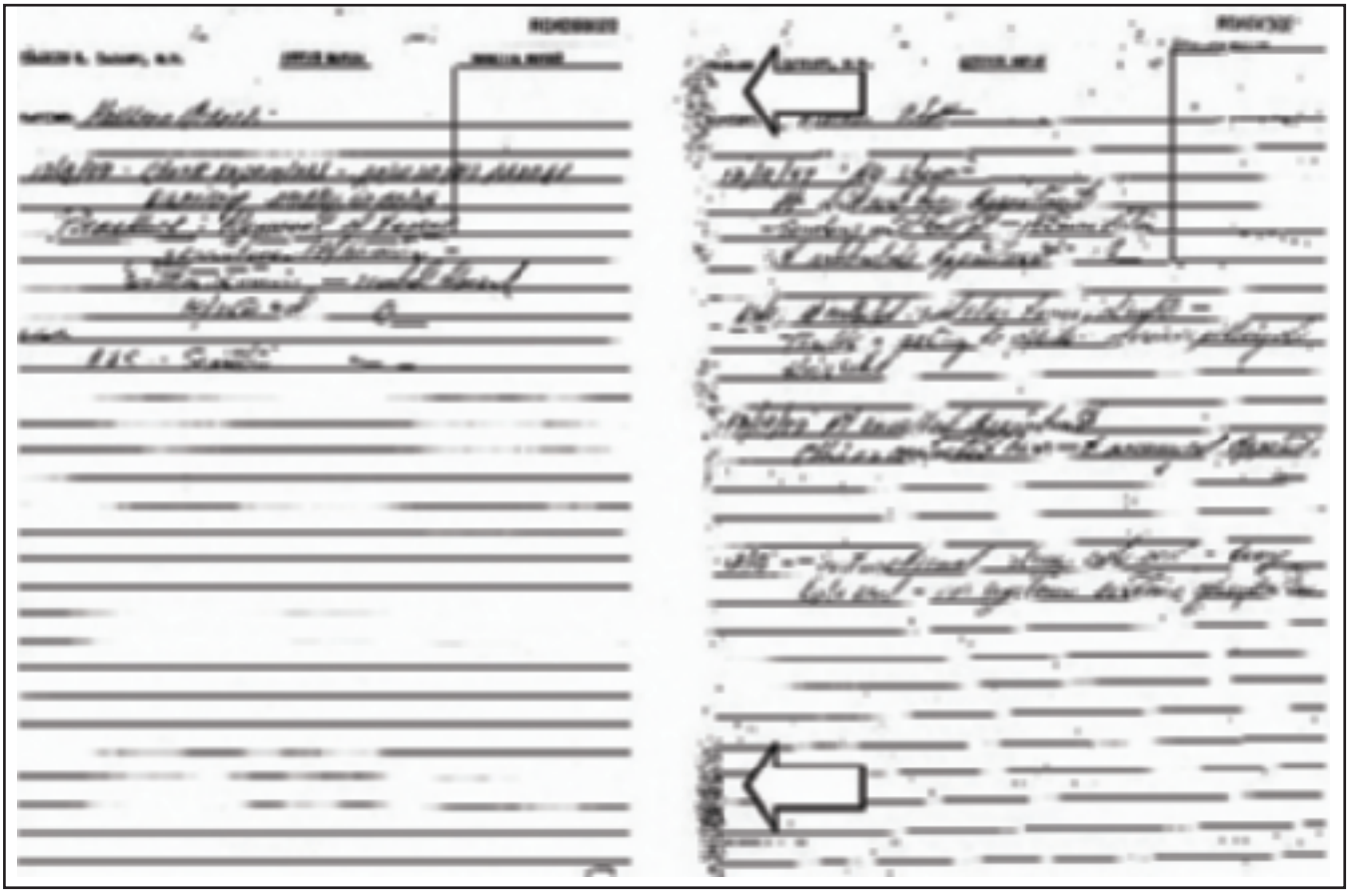


Figure 16.4 Comparison of photocopies

Investigators can also sometimes compare copy machine output. Debris, gripper marks, platen defects, and dirt can all contribute to what are termed *trash marks* on copies from a copier. These marks can change over time, so sometimes the material can even be dated. Look at some of the photocopied pages your teacher has handed out to the class. Are there any distinctive marks or patterns? (See Figure 16.4.)

Paper

Most modern paper is made from wood pulp. Some types of paper are manufactured mechanically, some are treated with chemicals, and some have additives, such as cotton fibers. Paper can be graded depending on the percentage of cotton fibers; from 25 to 50 percent cotton may be called *bond paper*. Mechanically produced wood pulp paper is used for newspapers. Special writing paper such as stationery is chemically treated with sodium sulfite. Shopping bags are treated with a sulfate for extra strength.

watermark: a design incorporated into the paper during manufacturing

Some manufacturers include their own **watermark** design during the manufacturing process by reducing the number of fibers within a certain patterned area. The manufacturer can change the watermark and sometimes can use it to indicate when the paper was manufactured and even where the paper was sold.

The forensic scientist may look at the following characteristics to identify paper:

- What raw material the paper is made from
- Color
- Density
- Watermarks
- Dyes or bleaches
- Fluorescence under ultraviolet light
- Thickness as determined by using a micrometer

Laboratory Activity 16.3

Analysis of Paper

You will analyze five different types of paper and compare them with an unknown, using some of the physical and chemical characteristics of paper.

Materials

For each group:

- known paper samples
- stereomicroscope
- ballpoint pen, gel pen, marker
- pH paper
- UV light
- digital balance

Caution: *Do not look directly at UV light. Doing so can damage the eyes.*

Procedure

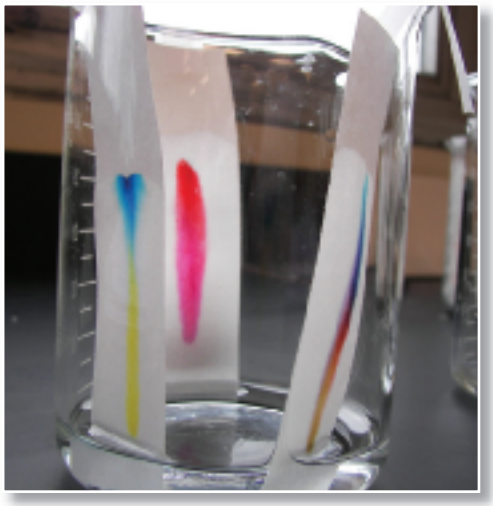
1. Using a stereomicroscope, examine samples of the various types of paper. Observe and describe the differences. Include the color, translucency, surface qualities (shiny, dull), and fiber structure. Record your observations for each sample.
2. Draw lines on the paper using a ballpoint pen, a gel pen, and a marker to observe the paper's absorbency. Look at it through the stereomicroscope. Record your observations for each sample.
3. Press a piece of wet pH paper against each sample and record the pH.
4. Weigh a 2.0-cm-square piece of each sample. Record your results.
5. Hold the paper up to the light; notice any watermarks. Record your observations.
6. Observe each sample under the UV light. Note whether any of them fluoresce.
7. Tear each piece and notice the tear pattern. Are there differences? Explain.
8. Devise an experiment to test "wet strength."
9. Make a data table to record all your observations of the variables you tested. Ask your teacher for an unknown sample and identify its type and possible source.

The U.S. Secret Service maintains an ink library that consists of approximately 8,500 ink-standard thin-layer chromatography slides. An ink library is also maintained by the U.S. Secret Service and the IRS which includes chemical analysis of more than 9,500 inks, dating from the 1920s.

Rolls of paper lined up for printing press

Inks

Investigators often compare inks by their composition. Sometimes they can even chemically establish how long the ink has remained on the paper.



Chromatograms of inks

Ink Comparison Using Paper Chromatography

Laboratory Activity 16.4

D. Warbucks lent money to an acquaintance, A. Orfan. He drew up two informal IOU notes, one for himself and one for Orfan. Unfortunately for Warbucks, he lost his. He asked Ms. Orfan for her copy of the note, and after viewing it he claimed that the sum of money of the loan and the due dates had been altered. We have obtained Ms. Orfan's original of the note she to gave Warbucks. The CSI team collected five markers from

Laboratory Activity 16.4, *continued*

Orfan's residence. Your job as an examiner of questioned documents is to determine whether the note has indeed been altered using one of Orfan's markers.

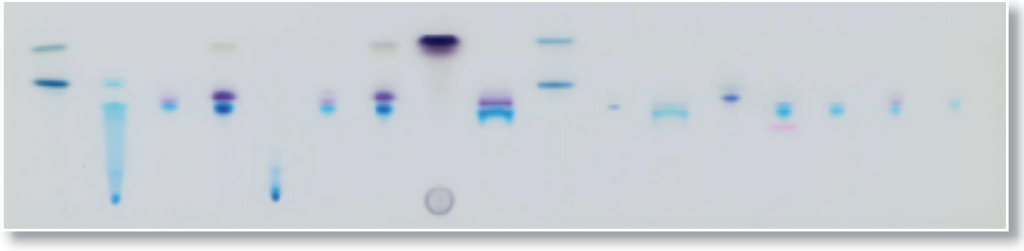
Materials

For each group:

- markers
- filter paper or chromatography paper
- distilled water
- 400-ml beaker with cover
- small test tubes
- open-ended capillary tube
- ruler

Procedure

You have enough experience now in chromatographic techniques to write your own procedure and record your observations. Make sure to document all procedures, observations, and conclusions. Determine which pen wrote the note. Tape chromatograms to your analyses, and keep them in your notebook.



TLC analysis of ballpoint pen inks.

Counterfeiting

Counterfeiting money is one of the oldest crimes known. It was a serious problem in the 19th century, when banks issued their own currency. In 1863 the United States adopted a national currency, but counterfeiting was still extensive. In 1865 the U.S. Secret Service was established to suppress counterfeiting.

Although counterfeiting has substantially decreased since the creation of the Secret Service, this crime continues to be a potential danger to the nation's economy and citizens. Production methods used in counterfeiting operations have evolved over the years

In a research study a few years ago, 68 one-dollar bills were collected at a food concession stand and at a grocery store. Examination showed that all but four of the bills were contaminated by bacteria such as *Staphylococcus* and *Streptococcus*, among other nasty types of bacteria. Wash your hands after handling money!

from the traditional method of offset printing to color copiers, scanners, computers, and inkjet printers.

U.S. currency has been changed over the past several years, beginning in 1996, to help thwart the efforts of counterfeiters, who are using the new technologies to copy money. The government has added new features to U.S. bills to protect citizens and businesses from being victims of counterfeiters.

Genuine currency paper has tiny red and blue fibers embedded throughout. Often counterfeiters try to fake the look of these fibers by printing tiny red and blue lines on their paper. Close inspection reveals, however, that on the counterfeit note the lines are printed on the surface, not embedded in the paper. It is illegal to reproduce the distinctive paper used in the manufacturing of U.S. currency (see Figure 16.5).

The fine border lines of a genuine note are clear and unbroken. On a counterfeit bill, the lines in the outer margin and scrollwork may be blurred or indistinct.

Genuine serial numbers have a distinctive style and are evenly spaced. The serial numbers are printed in the same ink color as the Treasury seal. On a counterfeit, the serial numbers may differ in color or shade of ink from the Treasury seal. The numbers may not be uniformly spaced or aligned.

Before the Civil War, American banks issued their own currency. Historians estimate that as much as one-third of all the money in circulation at the time was counterfeit! Even now, the Secret Service confiscates about $80 million in phony money each year.

On a genuine bill, the sawtooth points of the Federal Reserve and Treasury seals are clear, distinct, and sharp. The counterfeit seals may have uneven, blunt, or broken sawtooth points.

Figure 16.5 U.S. one hundred-dollar bill, front and back. Notice the clear details.

UNDERGROUND COUNTERFEIT FACTORY DISCOVERED IN COLOMBIA

The counterfeiting operation produced U.S. dollars by the millions, at a rate of $3 million per week.

—*from a BBC news bulletin, November 2000*

The genuine portrait appears lifelike and stands out distinctly from the background. The counterfeit portrait is usually lifeless and flat. Details merge into the background, which is often too dark or mottled.

Laboratory Activity 16.5

Know Your Money

Use your own currency, an ultraviolet light source, a stereomicroscope, and the website www.treas.gov/usss to answer the following:

1. What is U.S. currency printed on? Describe and draw what you see under a stereomicroscope.
2. What is a "star" note? What is the significance of the star?
3. What is microprinting, and where is it located on the bill? Sketch.
4. What is the "security thread"? What color is it in the $5, $10, and $20 bills?
5. Look at the security threads under the ultraviolet light source. Which of them fluoresce? What colors?
6. What five main characteristics of currency should you examine when looking for counterfeit bills?
7. From which Federal Reserve Bank did your bill originate? How do you know?
8. What is the "fine line printing pattern"? Where is it found?
9. Sketch the "fine line printing pattern" found on the $5, $10, or $20 bill.
10. What is a watermark? Where is it found on a $5 bill, and what does it look like? On the $10 bill?
11. What is color-shifting ink? Where is it found?

Caution: ***Do not look directly at UV light. Doing so can damage the eyes.***

Testing for Counterfeit Currency

Laboratory Activity 16.6

U.S. currency is printed on cotton- and linen-fiber paper with no starch **sizing**, unlike commercial paper. Remember the process of using starch to "fix" the iodine-developed fingerprints on paper? In this activity you will use the same reaction to test the validity of currency.

sizing: in paper manufacturing, starch or other fillers added to fill gaps, improve writability, and stiffen the paper

Materials

For each group:

- iodine solution
- paper samples
- U.S. currency
- cotton swabs

SAFETY ALERT! CHEMICALS USED

Always wear goggles and an apron when working in the labaratory

SAFETY NOTE *Also wear disposable laboratory gloves. Avoid inhalation, ingestion, or skin contact with chemicals.*

Procedure

1. Dip the cotton swab into the iodine solution and swipe it across a portion of each of the paper products.
2. Record your observations and attach each sample in your notebook.
3. Now do the same for the U.S. bill and note what happens. If you have any foreign currency, test it. Could such a test be used as a basis for a spot test by store clerks?

One hundred-dollar notes. Are they counterfeit?

Cybercrime

"Cyber" is a prefix used to describe a person, thing, or idea as part of the computer and information age. Derived from *kybernetes*, Greek for "steersman" or "governor."

Cybercrime can be defined as a criminal activity committed on the Internet. There are two categories of cyber- or computer crime: criminal activity that involves using a computer to commit a crime, and criminal activity that has a computer as a target. A whole new vocabulary has arisen to describe the many and evolving methods of such illegal activity. Examples include:

- Computer intrusions (**hacking**, **malware**, **virus**, **worm**, **Trojan horse**)
- Identity theft and Internet fraud (via **phishing**, **pharming**, **webjacking**, **Nigerian letter schemes**, **bots**, **zombies**, **spoofed websites**)

cybercrime: unlawful acts where the computer is either a tool or a target or both

hacking: unauthorized access to computer systems or networks

malware: software designed to infiltrate or damage a computer system without the owner's consent

virus: a program that attaches itself to a computer or a file and then circulates to other files and to other computers on a network

worm: a program that copies itself. The distinction between a virus and a worm is that a virus never copies itself; a virus is copied only when the infected file is run.

Trojan horse: a deceptively labeled program that contains at least one function that is unknown to the user and that harms the user. It does not copy itself.

phishing: attempting to steal personal information by sending out e-mails that appear to come from legitimate websites

pharming: redirecting users to false websites without them knowing it

webjacking: when a hacker gains access to and control over the website of another user

Nigerian letter scheme: a scheme where recipients are offered the "opportunity" to share in a percentage of millions of dollars if they first front some of their own money

bots: programs that provide attackers with unauthorized control of a computer (ro-"bot")

zombies: Internet computers infected with bots that secretly connect these PCs to websites or chat rooms where they can be controlled remotely. Some experts believe that networks of zombies, also called botnets, now send up to three-quarters of all spam.

spoofed websites: imitations of true, legitimate sites

crimeware: software tools built with the purpose of committing online scams and stealing information from consumers and businesses

denial of service (DoS): when a victim's computer is flooded with more requests than it can handle, causing it to crash

spam: junk or unsolicited e-mail sent by a third party; it can be used to deliver Trojan horses, viruses, and phishing attempts

piracy: the act of stealing valuable property by copying software, music, graphics/pictures, movies, and books that are available on the Internet

copyright: the legal right of ownership of work produced in books, music, plays, movies, graphics/pictures, and computer software. Copyrighted material cannot be copied without permission from the owner of the copyright.

- Transmission of illegal items and services (gambling, **crimeware**, child pornography, use by sexual predators)
- Extortion and harassment (**denial of service**, **spam**, stalking)
- **Piracy** (downloading to copy and sell material protected by copyright)
- Cyberterrorism (use of computers for communications, propaganda, and all of the above by terrorist groups)

The FBI estimates that cybercrime cost its victims about $200 million in 2006, and it is increasing yearly (see Figure 16.6). The most prevalent losses occur through auction fraud (see Figure 16.7 on page 506), although losses resulting from identity theft are insidious and probably increase that total a great deal. Look at the going rate of buying a person's identity off the Web (Table 16.1).

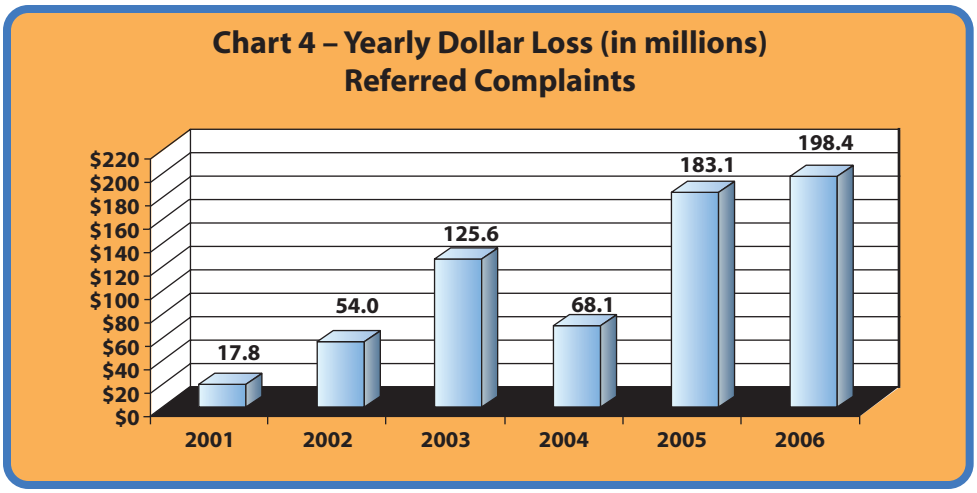


Figure 16.6 Cybercrime losses

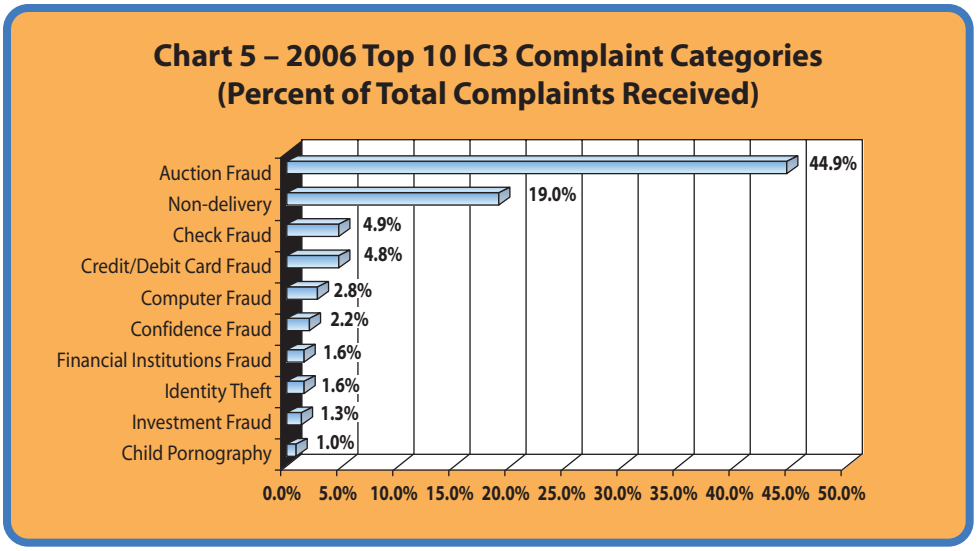


Figure 16.7 Types of cybercrime losses

computer forensics: the application of computer science to aid the legal process

The U.S. Patriot Act of 2001 allows for the search and seizure of computers.

Computer forensics is the application of specialized investigative and analytical techniques to identify, collect, examine, and preserve data from computer systems or networks so that it may serve as evidence in a court of law. As with other crimes, computer forensics investigations must follow the accepted standards of evidence as described in state and federal law. It's especially important to prevent suspect files from being altered or damaged through improper handling, viruses, electromagnetic or mechanical damage, and even booby traps.

Table 16.1: Goods Available for Sale on Underground Servers

Rank	Item	Percentage	Range of Prices
1	Credit cards	22%	$0.50–$5
2	Bank accounts	21%	$30–$400
3	E-mail passwords	8%	$1–$350
4	Mailers	8%	$8–$10
5	E-mail addresses	6%	$2/MB–$4/MB
6	Proxies	6%	$0.50–$3
7	Full identity	6%	$10–$150
8	Scams	6%	$10/week
9	Social Security numbers	3%	$5–$7
10	Compromised Unix shells	2%	$2–$10

Source: Symantec Corporation

16.2: The Case of the Hired Hacker

CASE STUDY

Our "entrepreneur" was still living at home with his parents when he launched two online sports apparel businesses specializing in "retro" or "throwback" sports jerseys. Sale of these jerseys is a booming, multi-billion-dollar industry, crowded with competitors, and in the early going he was selling only a couple of shirts a day. Then he allegedly came up with a plan to jump-start sales. Did it involve expanding his inventory? Overhauling his websites? Launching a marketing blitz? Nope. Our entrepreneur took another tack entirely. He went out and hired a hacker.

Why? Because he figured that his own sales would take off if he disabled the websites of his major competitors. He recruited a 16-year-old New Jersey hacker and gave him a list of ten sites to attack. The agreed-upon payment for his services? A watch and several pairs of knockoff designer sneakers.

In July 2004, the attacks began. From his home computer, the hacker infected as many as 2,000 unprotected computers across the country with "bots"—software programs that allowed him to remotely control the PCs. He then rigged these computers to bombard the competitor sites with data requests. The attacks—known as distributed denial of service, or "DDoS," attacks—quickly overloaded the sites' servers and knocked many of them offline for days. The hacker launched the attacks repeatedly for five straight months. One company was hit more than 30 times and suffered $600,000 in total losses.

But the damage didn't stop there. The attacks also brought down the companies that hosted the sites' servers and at least 1,000 other unrelated businesses as far away as Europe. Overall, the attacks caused at least $2.5 million in damage.

When one of the jersey retailers reported the attacks to law enforcement, the FBI and state police began a joint investigation. They even posed as a hacker in an online instant-message service, and the entrepreneur soon tried to hire them to commit even more attacks.

The upshot? In March 2005, the FBI simultaneously arrested the entrepreneur and the hacker. The entrepreneur was charged in a federal criminal complaint with conspiracy to use malicious programs to damage computers used in interstate commerce, an offense that carries a potential punishment of a fine, imprisonment for up to ten years, or both.

The hacker pleaded guilty as an adult in New Jersey State Superior Court, where he received a five-year prison sentence and a fine of $35,000. The 19-year-old entrepreneur was sentenced to 30 months in federal prison for recruiting a New Jersey teen to carry out computer attacks against competitors. He was also ordered to pay $504,495 to his victims, which included operators of competing websites as well as an Internet hosting company.

—from the FBI's Headline Archives, April 18, 2005
www.fbi.gov/page2/april05/hiredhacker041805.htm

This case illustrates a "domino effect" in just how many entities were affected, thus escalating the damages. Had the victim realized earlier that he was being subjected to DoS, perhaps the damage would have been less. Do you think the punishments were justified and reasonable?

Checkpoint Questions

Answer the following questions. Keep the answers in your notebook, to be turned in to your teacher at the end of the unit.

1. What are some common types of specimens submitted for document analysis?

2. Why would it be more difficult to individualize handwriting made by a fourth-grade student than the handwriting of an adult?

3. What makes an individual's handwriting unique?

4. Can the subconscious handwriting of two individuals be the same? Explain.

5. Where would you expect to see variations in handwriting?

6. Can one single handwriting characteristic be the basis for a positive identification? Explain.

7. When would the examiner have difficulties identifying handwriting?

8. What would an examiner look for to determine whether a signature has been traced?

9. What is a watermark, and how is it made?

10. What basic characteristics would a document examiner look at to determine if there is a match between two samples? Name five.

11. Explain the principles used in chromatography for ink analysis.

12. What methods can be used to "develop" writing indentations?

13. In Case Study 16.1, "Anonymous Writing," what techniques did the forensic document examiner use that you were familiar with?

14. You get an e-mail that says:

    "We suspect an unauthorized transaction on your account. To ensure that your account is not compromised, please click the link below and confirm your identity."

    What do you do?

    a. Click the link.

    b. Look at the URL and other parts of the e-mail. If it looks authentic, click the link.

    c. Ignore the request.

    d. Look at your account card and e-mail the company.

15. What is the difference between a computer virus, a worm, and a Trojan horse?

16. Use the Internet for this question. What is

    a. "vishing"?

    b. a keystroke logger?

    c. "Dumpster diving"?

    d. a cracker?

    e. a phreaker?

    f. a phracker?

Additional Projects

1. Prepare a half- to full-page summary of a selected forgery case such as:

   Hitler diaries

   Ossian manuscript

   Howard Hughes forgery

   Mormon and Freemason forgeries

   Lord Byron forgeries

   Texas Declaration of Independence

   Shakespeare forgeries

   Vineland map

   Or research the work of other famous forgers, such as:

   Thomas Chatterton

   George Psalmanasar

   John Payne Collier

   Alexander Howland Smith

   Thomas James Wise

   Or analyze the role of document examination in kidnappings, threats, and other crimes, such as:

   Lindbergh kidnapping

   Weinberger kidnapping

   anthrax letters

   Washington sniper letters

   JonBenet Ramsey letter

2. An oxidizing agent such as sodium hypochlorite (household bleach) can remove some inks from a document merely by soaking it for a day or more. Research methods to restore the "invisible" writing. Consider using mild heat, UV light, or reducing agents.

3. Can you make your own ESDA using a Tesla coil, a Mylar transparency, and copier toner?

Anthrax letters

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Rainis, Kenneth. *Forgery Crime-Solving Science Experiments*. Berkeley Heights, NJ: Enslow Publishers, 2006. Excellent little book with good information and activities.

Websites

http://qdewill.com; an interesting website with an article on the basis of handwriting, with some cases and examples

http://shop.symantecstore.com/store/symnahho/en_US/ContentTheme/pbPage.11ththreatreport/ThemeID.518300/pgm.9807200; annual report on criminal activity

www.compuforensics.com/links.htm; links

www.cybercrime.gov; lots of news headlines and brief cases

www.fbi.gov/libref/historic/famcases/weinber/weinbernew.htm; the Weinberger kidnapping

www.fbi.gov/libref/historic/famcases/lindber/lindbernew.htm; the Lindbergh kidnapping

www.fbi.gov/hq/lab/fsc/backissu/april2001/held.htm; the FBI's Questioned Documents Unit

www.ic3.gov/media/annualreport/2006_IC3Report.pdf; FBI report

www.treas.gov/usss; United States Secret Service website