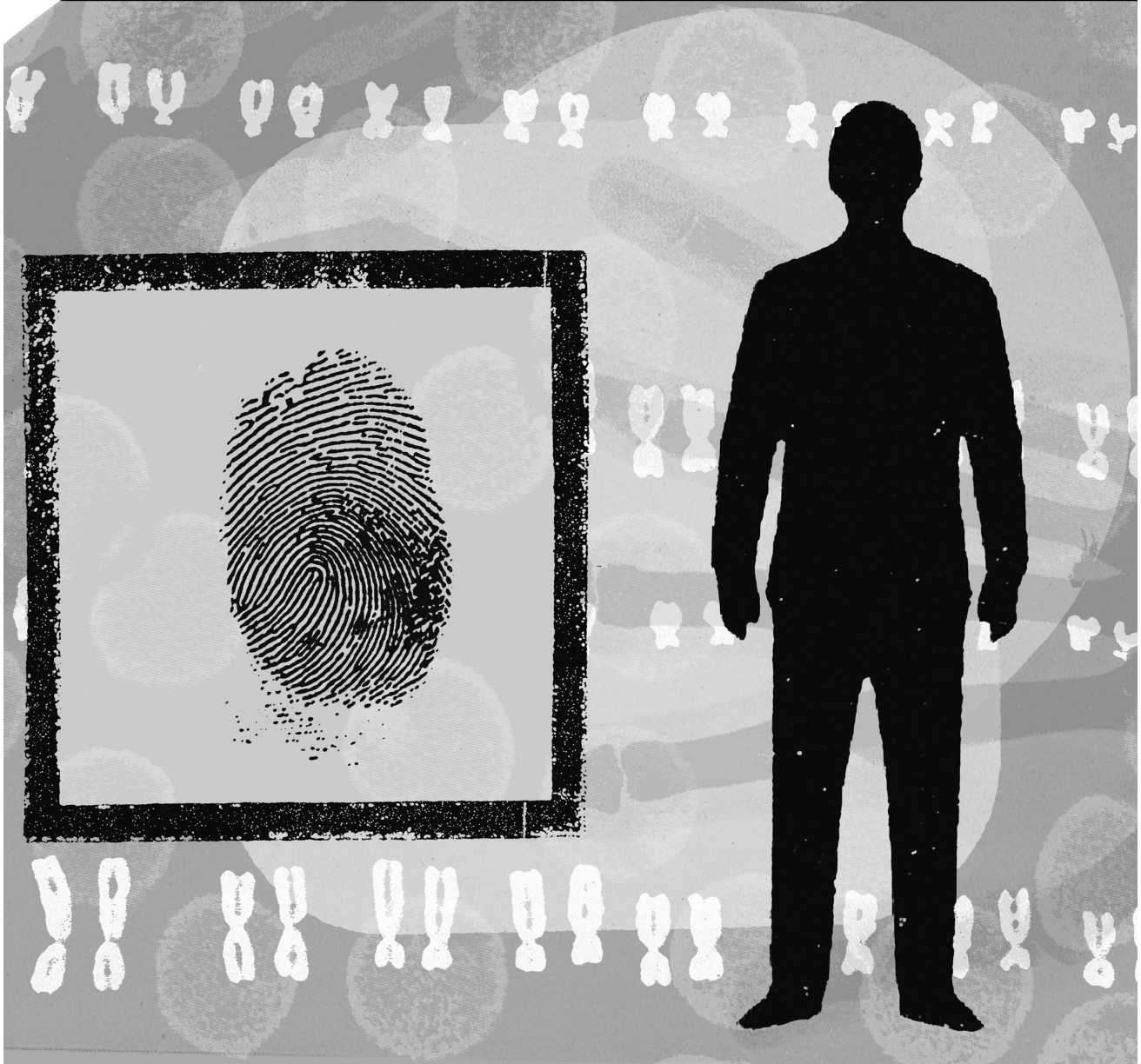


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top SHELF FORENSICS



Barbara Deslich
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BACKGROUND

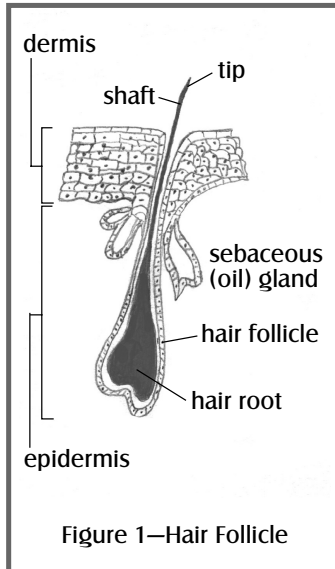


Figure 1—Hair Follicle

**Most people
lose about 100
scalp hairs
a day.**

Hair as Forensic Evidence

What Is Hair?

Hair is a filament composed mostly of **keratin**, a tough protein **polymer** of **amino acids**. Hair is produced in a bulb-shaped pocket in the skin, called a **hair follicle**. A complete hair has a root, shaft, and tip.

Why Do We Have Hair?

Hair provided our ancient ancestors with insulation to protect them from extreme temperatures as well as from harmful sun rays. It may have even served as camouflage, as it does in many animals. These days, we have clothes and sunscreens; however, 80% of lost body heat is through the head, so a good crop of hair can act as an insulator; and also as an attraction to the opposite sex. Hair at specific places on the body has a specialized purpose; for example, hair in our nose and ears acts as a dust filter; eyebrows were meant to shield our eyes from excessive sunlight and block sweat from our forehead.

What Attributes of Hair Make It Useful in Forensic Science?

There are about 100,000 scalp hairs on the average person. At any one time, 80–90% are growing; the remaining are in the process of separating from the hair follicle and eventually falling out—at a rate of about 100 a day. Not only is hair common, but it is quite durable and is resistant to physical and chemical degradation. It is also persistent in that it tends to cling to things, such as fabrics. Examination of hair cannot determine sex or age. However, new laboratory techniques have enabled DNA extraction from hair under favorable circumstances. **Nuclear DNA** can be found in the hair root or adhering tissue and **mitochondrial DNA** in the hair shaft.



Exploration Activities

1. Describe at least one scenario in which hair could link a suspect to a victim or crime scene.

Macroscopic Observation

2. Run a comb or brush through your hair to try to capture any hairs that are no longer growing, or use the ones your teacher asked you to bring from home. Now forcibly pull out several hairs from your scalp, using tweezers if available. Arrange the hairs on a piece of white paper. List below the characteristics that can be used to describe your hair. You may wish to use a hand lens.

Save your hair samples. You will need them later.



BACKGROUND

The Morphology of Human Hair

Structure

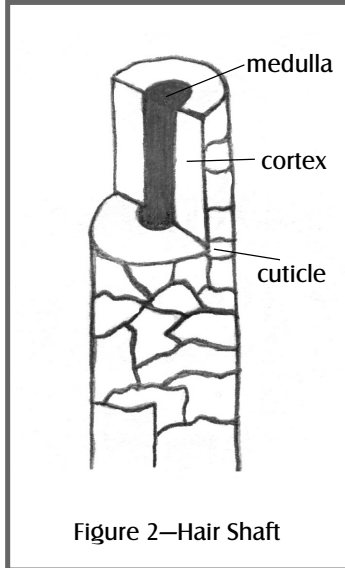


Figure 2—Hair Shaft

A hair shaft is composed of three parts—the **cuticle**, the **cortex**, and the **medulla**. The cuticle is the clear, outside covering of the hair shaft. It is made up of tough overlapping scales, such as on a fish or like shingles on a roof. Humans have a much finer pattern than animals and do not show much variation.

The cortex is made up of keratin molecules aligned parallel to the length of the shaft. Embedded within the cortex are pigment granules that give hair a lot of its color (black, brown, yellow, or red). Gray or white hair is the absence of such granules.

The medulla is a row of cells running along the center of the cortex like a canal. It may appear dark or translucent depending on the presence of air, liquid, or pigments, and it can be continuous, interrupted, or fragmented. Human hairs generally show fragmented or no medulla except for American Indians and Asians for whom the medulla is usually continuous.

Configuration

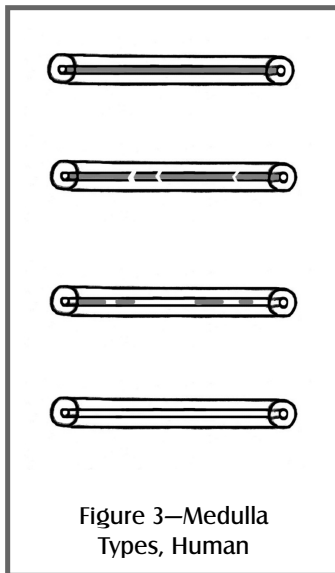
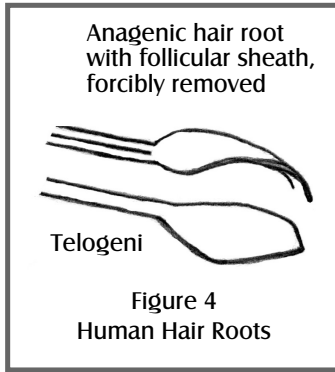


Figure 3—Medulla Types, Human

The shape of hair can also vary. It can be straight, curly, or kinky, depending on whether it is round, oval, or crescent-shaped in cross section. It is difficult to prepare a cross section of hair for microanalysis. Sometimes one can tell more about the cross section by twisting a strand back and forth on a microscope slide under low magnification. Interestingly, hair from a beard is often coarse and triangular. Particular configuration elements are statistically more common to racial origin, but there are many exceptions.

Diameter

The diameter of human hair ranges from 25 to 125 micrometers (μm). Generally, individuals have small variation within the type of hair (i.e., scalp, beard, chest, pubic, etc.).



Root

Head hair grows at a rate of about 1 cm per month and is replaced about every 3 to 5 years with new hair. There are three stages of growth: the **anagen phase** (80–90% of hair follicles at any one time); the **catagen phase**, which is an intermediate stage; and the **telogen phase** (18–10%), in which the follicle is ready to push out the mature hair. The hairs on your brush, comb, or shoulder are telogen hairs and should reflect that in the bulbous appearance of the root with few if any pigment granules near it. Hairs that have been forcibly removed from the scalp in the anagen phase of growth may still have follicular tissue attached, may appear stretched, and may have pigment granules evident since the hair was still growing.

Tip

The tip of the hair shaft will taper to a point if it has not been cut or abused for a while. Hair that has been recently cut is squared off at the tip, but within two to three weeks it becomes rounded. Frayed hair or split ends result from dryness and lack of care (no conditioners), harsh chemicals (bleaches), or overuse of a blow dryer (too much heat).

The hair's root is embedded in the follicle, which is in equilibrium with the body's blood supply. Whatever is taken into the body is distributed into the growing hair. This is important in analyzing hair for drugs and poisons. Since hair grows at a fixed rate, a time frame of the introduction of a foreign substance can sometimes be established.



Student Lab: Microscopic Examination of Human Hair

You will be using a compound microscope to observe the structure of the hairs you have collected so far.

Materials

- Collected hair samples
- Compound microscope
- Microscope slides
- Cover glasses
- Scissors
- Mineral oil or glycerin

Procedure

1. Place the hair sample on a microscope slide and add a drop of mineral oil or glycerin (water will do in a pinch). Anchor it with a cover glass.
2. Start with the lowest magnification of the microscope, 40×. Adjust the light through the condenser for optimum viewing. Look at the entire length of your hair samples by pulling them through the liquid under the cover glass.
3. Go to 100× magnification. Draw a typical part of your hair, labeling the cuticle, medulla, and cortex. Note the degree of pigmentation in the cortex. Make your drawing at least twice as large as what you see.
4. Calculate the medullary index (MI). This is the ratio of the diameter of the medulla to the diameter of the hair. It is generally $\frac{1}{3}$ or less in humans. Estimate it if you have no means of measuring. (MI = diameter medulla / diameter hair)
5. Twist a strand of hair back and forth on a microscope slide under low magnification. Try to tell if the cross section of hair is round, oval, or crescent-shaped.
6. The diameter of your hair can be estimated by laying a piece of wire of known diameter next to it, or comparing it to the field of view, if you know that. Some microscopes have a reticle, which is a scale in the eyepiece. Once calibrated, it can be used to measure the diameter. Or, one can use a ruled stage micrometer, which is a microscope slide with lines 0.01 or 0.001 mm apart. Measure the diameter of a strand of your hair.

7. Examine the root end of your hair samples at 40× and higher, if necessary. You should look at an anagenic root that was forcibly removed and a telogen, mature hair root that you obtained by combing or brushing. Sketch and label the samples you observe.
8. Cut a sample of your hair with sharp scissors. Examine the tip. Compare it with the tip of one or two of your samples. Draw and label each tip. Bleached hair will appear light, even yellowish.
9. Observe a hair strand that has been dyed if one is available. The dye penetrates the cuticle and into the cortex.
10. Pluck a hair from your eyebrow, eyelash, arm, or other part of your body and compare it to your scalp hair. Draw and label the sample.
11. Examine the structure of a section of scalp hair from three other students. Draw and label a typical section from each person. You should be looking at color, medulla, diameter, and any unusual characteristics.

Conclusions

1. In step 3 in the Procedure section, are the hairs you observed the same throughout?
2. What is the value of the medullary index as found in step 4 in the Procedure section?
3. When you stretched your hair in the earlier section of the lab, was it straight, curly, or kinky? What did you observe when you twisted the hair in step 5 in the Procedure section?
4. Is the diameter of your hair constant for most of its length?
5. Is there evidence of any hair treatment in the samples you observed in step 8? How can you tell that a hair has been dyed?
6. How does the hair you observed in step 10 in the Procedure section compare to your scalp hair? How does it differ? What significance does this have?
7. How do the hairs you observed in step 11 differ from one another?

8. Fill out Table 1. In boxes 1, 2, 3, and 4 write the names of the students whose hair you studied.

TABLE 1 The Comparison of Characteristics of Human Hair					
Characteristic	Yourself	1	2	3	4
Color					
Length (cm)					
Medulla					
Diameter					
Configuration					
Tip					
Cosmetic Treatment					

9. What have you learned? Based on the data in the table above, can hair be used as evidence? Under what circumstances?
10. Your teacher will poll the class and tabulate the seven scalp-hair characteristics listed in Table 2 for each student. Place the number of students with that specific trait in the third column; include yourself. For example, if there are 13 blondes in your class, place the number 13 in the third column opposite blonde.

TABLE 2 Comparison of Scalp Hair Characteristics for the Entire Class

Characteristic	Yours	Everyone
1. Color White Gray Blonde Brown Black Red No color—bald		
2. Length (cm) Under 3 cm 3–8 cm 8–15 cm 15–30 cm 30–50 cm over 50 cm		
3. Medulla Absent Fragmentary Interrupted Continuous		
4. Diameter 20–40 μm 40–60 μm 60–80 μm 80–100 μm 100–120 μm		
5. Configuration Straight Curly Kinky		
6. Tip Cut Split Frayed Rounded Pointed		
7. Cosmetic Treatment None Bleached Dyed Other		

11. Based on the data tabulated in Table 2, can hair be used as evidence? Under what circumstances? Within your class, is your hair unique? Could it be classified as individual evidence?



Exploration Activities

Probabilities

Hair is considered class evidence in forensic science. Depending on the circumstances, its evidentiary value or importance is based on statistics. What are the chances that a hair came from a suspect or a victim? If there are only three possible suspects, a blonde, a brunette, and a redhead, and the circumstantial evidence consists of a red hair, then there is a 100% probability that the redhead committed the crime. However, if all three suspects have red hair, then the probability of choosing the perpetrator is one out of three. Not good enough! In this case, one would hope for more hair characteristics, or other circumstantial evidence. As the number of characteristics or objects linking a suspect increases, so does the probability of association or involvement.

1. A class has the following makeup:

Hair Color	Girls	Boys
Blonde	6	4
Brown	4	7
Red	0	1
Black	6	2

- a. What is the probability in this class of selecting the person who left a red hair at a crime scene? Show your work.

- b. A black hair?

- c. If all the boys and $\frac{1}{2}$ of the girls have short hair in each color category, what is the probability of finding the student who left a long brown hair?

- d. If there are 630 students in the school, statistically how many boys would have black hair?

 - e. In class, if two blondes have a fragmented medulla and one other blond has hair longer than 20 inches, how many girls in school would you expect to have blond hair longer than 50 cm with a fragmented medulla? Does this make sense, or are the odds skewed?
2. Someone in your class has stuck a wad of bubble gum on the teacher's desk. Embedded in the top of it is a hair. Examination finds that it is brown, 5 cm long from bulb to tip, the medulla is fragmentary, the shaft is 85 μm in diameter, the tip is cut, and there is no evidence of any treatment. What is the probability that you can identify the culprit? Use the data from Table 2. Explain. (You may wish to reread the discussion on Probability and Statistics in the Forensics Background chapter.)

 3. Compare the probability you determined above to the actual, **empirically** derived results from question 16 of the lab. Remember that the higher the probability of identification (or the lower the probability of finding another student with the same hair characteristics), the more likely that the hair from the bubble gum approaches being individual evidence.

 4. If you consider your class as representative of your school's student body, how many students would you expect to find with the exact hair characteristics of the unscrupulous bubble-gum wadder? Show your work.

 5. Why is probability important in forensic evidence?



Student Lab: Comparison of Animal and Human Hair

The first question asked in studying hair evidence is whether it is human or animal hair. It is estimated that there are 70,000,000 cats in the United States, 60,000,000 dogs, and millions of other domesticated animals. The following lab will explore how animal hairs differ from those of humans.

Materials

- Animal hairs
- Human hair
- Compound microscope
- Microscope slides
- Cover glasses
- Mineral oil or glycerin
- Alcohol
- Tissues
- Clear nail polish

Procedure

1. Use animal hair that you have collected, or obtain a sample from another student or your teacher. Place the hair sample on a microscope slide and add a drop of mineral oil or glycerin (water will do in a pinch). Anchor it with a cover glass.
2. Examine the sample. Draw and label what you observe. Be sure to note the animal involved.
3. Measure or estimate the medullary index (MI). This is the ratio of the diameter of the medulla to the diameter of the hair. Animal hairs have indices greater than $\frac{1}{3}$. (MI = diameter medulla/diameter hair)
MI (human) $< \frac{1}{3}$
MI (animal) $> \frac{1}{3}$
4. If possible, obtain slides of other animal hairs and make drawings of cat, dog, horse, deer, and two others of your choice. Don't forget to make the drawings twice as large as what you see. Measure the MI for each sample.

The cuticle of human hair is difficult to observe under a microscope because it is close-packed, transparent, and fine. Its structure can be delineated, however, by making a cast of hair.

5. Clean a strand of your hair by pulling it through a folded tissue moistened with alcohol to remove grease and oil.
6. Coat a microscope slide with clear nail polish and press your hair into it. After the polish becomes sticky but not dry, remove the hair and examine the cuticle impression at 40× or 100×. Draw a picture of what you observe.
7. The cuticles of different animal hairs can be quite varied and are generally much coarser than those of humans. Make a cast of your animal hair for comparison and draw it. Compare the drawing of the cuticle from your animal hair to those of other animals from your class.

Conclusions

1. How do animal hairs differ from the human hairs you have observed?
2. What is the value of the medullary index as found in step 3 of the Procedure section?
3. What is the value of the medullary index for each sample you observed in step 4 of the Procedure section?
4. How does the drawing of the cuticle from your animal hair compare to the drawings of others in your class?



Forensic Activity: Dognapping

Ms. Abigail Beauceron, proud owner of the grand-prize winner at the prestigious 2003 Westminster Kennel Club Dog Show, was leaving Madison Square Garden in the late afternoon when someone came up behind her, knocked her down, bundled FuFu in a blanket, and quickly ran out the nearby exit to the parking garage. FuFu is a Black Russian Terrier with dark-gray hair.

The event was captured on a security video, but the only description obtained was that the perpetrator was wearing a dark jacket and a baseball cap. Police found a rather smelly wool blanket by an empty parking spot near the exit in question. cursory examination by the officers showed some hair sticking to the fabric.

Early next morning, Ms. Beauceron received an unwelcome e-mail Valentine demanding \$20,000 for the safe return of FuFu, with details of the exchange to be sent at a later time. The police quickly traced the message back to an Internet room maintained for patrons of the public library. At the time the e-mail was sent, library records showed that seven people had used the facility so far that day. While the library's time records were not precise, they did keep a sign-in sheet of each day's users.

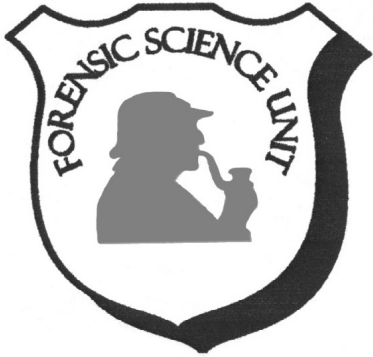
The police detectives doggedly paid a visit to each suspect on the list and, brandishing a warrant, searched each residence and vehicle. They also took samples of scalp hair and any facial hair. By the end of the day, they were dog-tired, but satisfied with the information they had obtained.

The following facts about each suspect were taken from the police report:

- George Shepherd. DOB 4-13-79. White male. Ht 5-8. Wt 160 lbs. Eyes brown. Hair brown. Occupation: Assistant manager of a fast-food restaurant next to the Coliseum. Pets: One cat.
- Patricia Barbet. DOB 2-18-42. White female. Ht 5-4. Wt 110 lbs. Eyes blue. Hair white. Occupation: Real-estate broker. Pets: Three cats and a turtle.
- Helmut Weimaraner. DOB 7-2-65. White male. Ht 5-7. Wt 305 lbs. Eyes brown. Beard brown. Occupation: Accountant. Pets: None.
- William Setter. DOB 5-28-72. Black male. Ht 5-11. Wt 185 lbs. Eyes brown. Hair black. Occupation: Security guard at the Coliseum. Pets: Light-brown collie and a parrot.

- Akita Lau. DOB 8-7-70. Asian female. Ht 5-3. Wt 107 lbs. Eyes brown. Hair black. Occupation: Graphic designer. Pets: Doberman Pinscher.
- Fred Basset. DOB 8-28-61. White male. Ht 5-9. Wt 175 lbs. Eyes blue. Hair blonde. Occupation: Insurance salesman. Pet: Scottish Terrier with dark-gray hair. This dog was runner up for the last two years at the Westminster Show.
- Maurice Spaniel. DOB 9-14-78. White male. Ht 5-8. Wt 170 lbs. Eyes blue. Hair bald, no other facial hair. Occupation: Professional boxer. Pets: Irish setter with brown hair and a golden retriever with orange-brown hair.

1. Based on what you know now, do you have any thoughts on who would be your prime suspect(s)? Why?
2. Each investigative group will receive a package of evidence containing eight envelopes of hair samples. Your job is to ascertain if the evidence submitted can lead to the kidnapper. A Crime Report form must be completed independently by each investigator in each group with the realization that any one member of the group may be called as an expert witness at trial. Therefore, any conclusions must be justified and able to withstand cross-examination.
3. Can you tell what color a cat is from examination of several of its hairs?



CRIME REPORT

CASE NO. _____ DATE _____

NATURE OF CRIME _____

DATE OF OCCURENCE _____

TIME OF OCCURENCE _____

LOCATION _____

VICTIM _____

BRIEF HISTORY OF CASE:

TYPE OF EVIDENCE SUBMITTED FOR EXAMINATION _____

List each individual item: use Q for questioned (source unknown);
K for known (source established).

BRIEF DESCRIPTION OF METHODS USED:

CASE NO. _____

RESULTS:

CONCLUSIONS:

SIGNATURE _____ DATE _____

NAME OF INVESTIGATIVE GROUP _____