

Justice and medicine: the rare art of forensic pathology

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The only clues were a wedding photograph and a skull.

The task was to identify the victim of a crime.

The techniques used were pathology and photography. By photographing the skull at exactly the same angle as the face in the photograph and superimposing one over the other, the victim was positively identified.

This is one aspect of the work of the forensic pathologist, a kind of modern medical Sherlock Holmes. Backed up by impressive technology and using methods borrowed from several other disciplines, the forensic pathologist helps policemen understand the meaning of medical findings.

"Forensic pathology," explains Dr. James Ferris, deputy director of forensic pathology for Ontario, "is the examination of organs and tissues to determine the medicolegal significance of disease. In actual practice, our role is to conduct a medicolegal examination on behalf of the coroner and police."

In a sense, the pathologist works

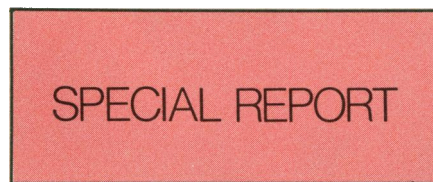
like a detective to identify bodies that cannot be identified visually, to describe the cause of unnatural and sudden deaths, to match weapons to wounds and ultimately to present his findings in court.

According to Dr. John Hillsdon Smith, director of forensic pathology for Ontario, there are few full-time forensic pathologists in the world. In Ontario there are three and two of

since 1973 and is described in the ministry's annual report as a "second-to-none forensic pathology department with full 'back-up' facilities for medicolegal autopsies". In Ontario, all sudden and unexplained deaths are investigated initially by a coroner, as explained in another article in this issue. In 1975, 28 000 such investigations were carried out in the province and 8300 medicolegal autopsies were ordered by the coroners. The majority of these were done by 248 pathologists in the province, on a fee-for-service basis, at present \$150 an autopsy.

At the Toronto centre, in 1975 the full-time staff carried out 108 medicolegal autopsies, examined 21 skeletal remains and put in 54 court appearances, about 300 hours of court time. Ferris and Hillsdon Smith do the majority of homicide cases for Metro Toronto as well as any complex or difficult cases from the rest of Ontario.

"By complex," explains Hillsdon Smith, "I mean particularly nasty ones or ones the pathologist feels he can't



them, Hillsdon Smith and Ferris, work at the forensic pathology agency at 26 Grenville Street in Toronto. Canada has approximately 18, of whom 10 or 11 are in Quebec.

Under the solicitor general of Ontario, the agency has been in operation



Identification of skull is illustrated by these photographs. A wedding picture of the probable dead person was obtained and the head enlarged. A photograph of the skull at the same size and angle was taken and superimposition of pictures 2 and 3 showed that the bone structures were identical.

handle or doesn't have the facilities to handle."

Both Ferris and Hillsdon Smith agree anatomical pathology is the closest discipline to forensic pathology. "The difference between a hospital pathologist and a forensic pathologist," explains Ferris, "is the anatomical pathologist has not been paid to take the time to prepare and present cases in court — he could never be compensated adequately. A busy hospital pathologist would waste hours hanging around in courtrooms. He cannot afford the time."

One of Hillsdon Smith's main areas of interest is in identification, working on freshly dead bodies, partial bodies (the result of explosions, fire or decomposition), right down to skeletal remains. "These can be very fragment-

ary," he says. "Some of these (the bones they are given to identify) are over 100 years old, ranging to 2000 or 3000 years old." Hillsdon Smith estimates he and Ferris do about 60 homicide cases a year and 80 to 90 identification cases, the latter of which are very time-consuming.

In most cases, the bodies are identified by relatives. If that is not possible, identification by fingerprints is done if records are available and the prints haven't been damaged. Failing that, a dental comparison is done — "a numerically very useful technique," says Hillsdon Smith. "If we've gone those routes and there is still no identification, other routes are possible. If the police have an idea as to who the body might be, they can do a post- and antemortem x-ray comparison, if rec-

ords are available."

But if the police have no idea of who the person is, certain characteristics are ascertained from the body itself, depending on the condition it is in, such as sex, age, height, weight, build, abnormalities, as well as hair colour, skin colour, shoe size, waist size, lifestyle and any other information that could be useful to the police. The police then run the data through a computerized file of all reported missing persons in Canada. They can pull out the files that correspond and try to compare what the pathologist has found with existing medical and dental records.

If those methods have failed, another technique is a postmortem x-ray of the bones.

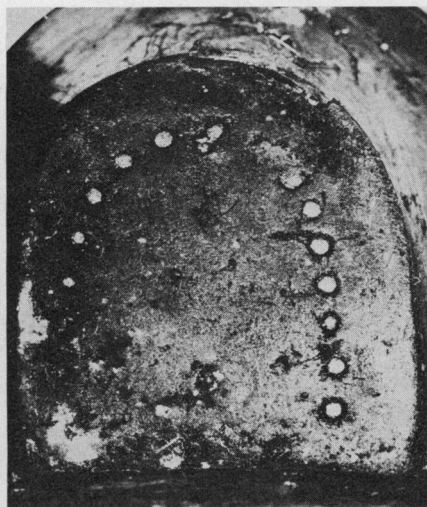
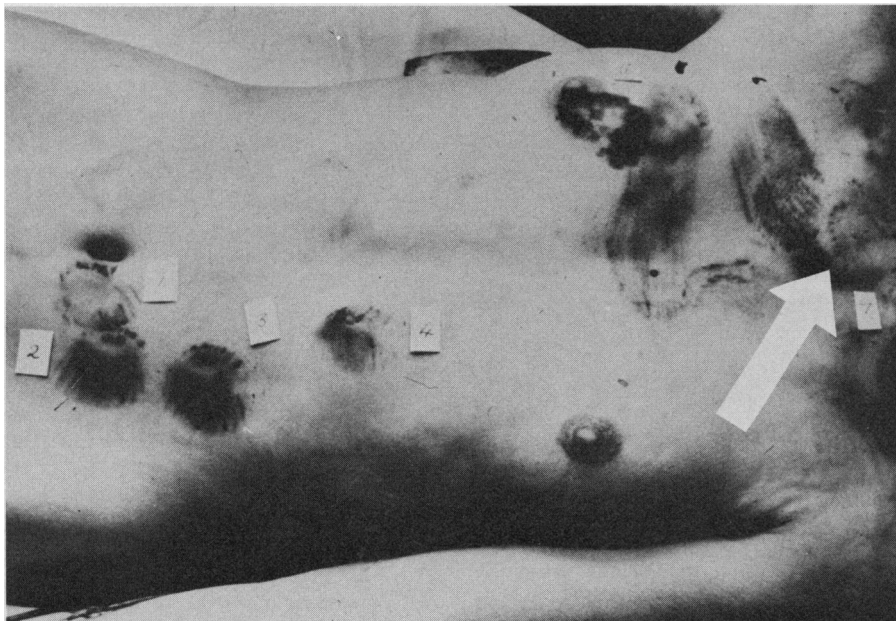
"We believe," explains Hillsdon Smith, "that the fine bony structure can be looked at like a fingerprint . . . that it is peculiar to each of us." He says that holds true for people over age 17 and under 55 — after the bones are fully grown and before senile changes occur. "But to be able to go into court and compare ante- and post-mortem x-rays," he says, "we've got to have background proof (that the hypothesis is true)." The centre is now in the process of x-raying 500 bodies showing those areas commonly x-rayed during life. They compare all the x-rays, and if they can't find two alike, Hillsdon Smith says he feels it is "a good statistical basis" for the theory.

He believes the hypothesis is valid for two reasons — simply from his personal observation and experience and because the development of the fine bony structure is dependent on so many things. Initially the bone structure is inherited, but it is subsequently influenced by diseases and trauma during life. The structure is also affected by muscle pull. On the forearm bones, for example, 25 to 30 muscles play on them. Some people use them, others don't.

The trained pathologist can tell if the person was right-handed or left-handed and if he did manual or sedentary work by examining the bones, because of the variability of the pull of the muscles. "I feel we are really onto something solid in this field," says Hillsdon Smith.

Certain features of the skull have been proved unique to each person. The frontal sinus is unique in people over age 15, for example, and "sinus prints" are a means of identification. The mastoid process is also said to be unique, but Hillsdon Smith says he is "not convinced" of that one.

If all those techniques have failed to identify a body, but the police have a suspicion of who it might be, the pathologist can ask for a photograph taken during life. If the investigators



A young woman's naked body was found to bear many patterned external wounds (top). Some of these, on the abdomen, superficially resembled bite marks. However, comparison of a horseshoe-shaped impression over the lower neck area (left) enabled a positive match with the right heel characteristics (right) of a pair of shoes seized from a suspect.

Vibramycin*

DOXYCYCLINE

VIBRAMYCIN PRODUCT INFORMATION

Capsules, Oral Suspension and Intravenous

ACTION VIBRAMYCIN is a broad-spectrum antibiotic and is active against a wide range of Gram-negative and Gram-positive organisms. VIBRAMYCIN exerts its antimicrobial effect by inhibition of protein synthesis.

INDICATIONS AND CLINICAL USE

Oral VIBRAMYCIN is indicated for the treatment of:—**Pneumonia:** Single and multilobe pneumonia and broncho-pneumonia due to susceptible strains of *Pneumococcus*, *Streptococcus*, *Staphylococcus*, *II. influenzae* and *Klebsiella pneumoniae*. **Other Respiratory Tract Infections:** Pharyngitis, tonsillitis, sinusitis, otitis media, bronchitis caused by susceptible strains of β -hemolytic *Streptococcus*, *Staphylococcus*, *Pneumococcus* and *II. influenzae*. **Genito-urinary Tract Infections:** Pyelonephritis, cystitis, urethritis, gonococcal urethritis caused by susceptible strains of the *Klebsiella-Aerobacter* group, *E. coli*, *Enterococcus*, *Staphylococcus*, *Streptococcus* and *Neisseria gonorrhoeae*. **Skin and Soft Tissue Infections:** Impetigo, furunculosis, cellulitis, abscess, wound sepsis, paronychia, caused by susceptible strains of *Staphylococcus aureus* and *albus*, *Streptococcus*, *E. coli*, and the *Klebsiella-Aerobacter* group. **Gastro-intestinal Infections** caused by susceptible strains of *Shigella*, *Salmonella* and *E. coli*. For patients in whom oral therapy may not be feasible for such reasons as dysphagia, nausea, gastro-intestinal intolerance, unconsciousness, lack of cooperation, traumatic or surgical wounds of the gastro-intestinal tract or intestinal obstruction, VIBRAMYCIN I.V. may be used. The clinical efficacy of VIBRAMYCIN I.V. has been confirmed in cases of infections caused by *E. coli*, *Klebsiella* and *Staphylococcus aureus*.

CONTRAINDICATIONS VIBRAMYCIN is contraindicated in individuals who have shown hypersensitivity to tetracyclines.

WARNINGS As with other tetracyclines, VIBRAMYCIN may form a stable calcium complex in any bone-forming tissue, though *in vitro* it binds calcium less strongly than other tetracyclines. Though not observed in clinical studies to date, it should be anticipated that like other tetracyclines the use of VIBRAMYCIN during tooth development (last trimester of pregnancy, during lactation, neonatal period and early childhood) may cause discoloration of the teeth. Though more commonly associated with long term use of tetracyclines, this effect has also been known to occur after short courses. **INFUSION OF VIBRAMYCIN I.V. SHOULD BE CARRIED OUT AT A RATE NOT TO EXCEED 200 MG. OVER A 30-MINUTE PERIOD.**

PRECAUTIONS In clinical studies to date, VIBRAMYCIN administration did not lead to increased serum levels nor to an increase in the serum half-life of doxycycline in patients with impaired renal function. VIBRAMYCIN in normal dosage may be used to treat these patients. Although no evidence of increased toxicity has been observed in such patients, the potential for increased hepatic or other toxicity should be considered until further data on the metabolic fate of doxycycline under these conditions become available. Liver function tests should be carried out at regular intervals on patients receiving high doses for prolonged periods of time. Concurrent administration of VIBRAMYCIN and agents known to be hepatotoxic should be avoided if possible. The use of antibiotics may occasionally result in overgrowth of non-susceptible organisms; thus, observation of the patient is essential. There is evidence to suggest that VIBRAMYCIN, may have less effect on the gut flora than other tetracyclines. VIBRAMYCIN should not be administered to pregnant and lactating women or neonates until its safety in such cases has been established beyond all reasonable doubt, unless in the judgment of the physician the potential benefit to the patient outweighs the risk to the fetus or child. Certain hypersensitive individuals may develop a photodynamic reaction to sunlight during treatment with VIBRAMYCIN. If this or any other allergic reaction should occur, medication should be discontinued. Increased intracranial pressure with bulging fontanelles has been observed in infants receiving therapeutic doses of tetracycline. Although the mechanism of this phenomenon is unknown, the signs and symptoms have disappeared rapidly upon cessation of treatment with no sequelae.

ADVERSE REACTIONS As with other broad-spectrum antibiotics, gastro-intestinal disturbances such as nausea, vomiting and diarrhoea, as well as glossitis, stomatitis and proctitis may occur, but have rarely been sufficiently troublesome to warrant discontinuation of therapy. As with other tetracyclines, elevation of SGOT or SGPT values, anemia, neutropenia, eosinophilia, leukopenia or elevated BUN has

been reported, the significance of which is not known. In clinical efficacy studies to date, VIBRAMYCIN I.V. was generally well tolerated. The most frequent side effects reported with the preparation were burning at the site of infusion, and phlebitis. The frequency and severity of the reactions can be minimized by using dilute solutions of the formulation and by avoiding diffusion of the solution into surrounding tissues.

SYMPTOMS and TREATMENT OF OVERDOSAGE
Gastric lavage if necessary.

DOSEAGE AND ADMINISTRATION ORAL: The recommended dosage of oral VIBRAMYCIN in adults for the majority of susceptible infections is a single loading dose of 200 mg. on the first day of treatment followed by a maintenance dosage of 100 mg. once daily at the same time each day thereafter. The recommended dosage schedule for children over one month weighing up to 100 pounds is a single loading dose of 2 mg./lb. of bodyweight on the first day, followed by a maintenance dosage of 1 mg./lb. once daily at the same time each day thereafter. As absorption is not significantly affected by food or milk, VIBRAMYCIN should be given with or after a meal thus minimizing the possibility of gastric upset. Antacids and iron preparations impair absorption and should not be given concomitantly to patients taking oral VIBRAMYCIN. In severe infections in adults such as lung abscesses or osteomyelitis, and in chronic urinary tract infections, a single daily dose of 200 mg. may be used throughout. For more severe infections in children, up to 2 mg./lb. of bodyweight may be given. Therapy should be continued after symptoms and fever have subsided. It should be noted, however, that effective antibacterial levels are usually present 24 to 36 hours following discontinuance of VIBRAMYCIN therapy. When used in streptococcal infections, therapy should be continued for 10 days to prevent the development of rheumatic fever or glomerulonephritis. For treatment of acute gonococcal infections, the recommended dosage is 200 mg. stat. and 100 mg. at bedtime the first day, followed by 100 mg. b.i.d. for 3 days. No alteration in recommended dosage schedule need be made when treating patients with impaired renal function.

INTRAVENOUS; INFUSION OF VIBRAMYCIN I.V. SHOULD BE CARRIED OUT AT A RATE NOT TO EXCEED 200 MG. OVER A 30-MINUTE PERIOD. Rapid administration is to be avoided. Parenteral therapy is indicated only when oral therapy is not practical. Oral therapy should be instituted when feasible. If intravenous therapy is given over prolonged periods of time, thrombophlebitis may result. The dosage and frequency of administration of VIBRAMYCIN I.V. differ from other tetracyclines. Thus therapeutic antibacterial serum activity will usually persist for 24 hours following recommended doses of VIBRAMYCIN I.V. Exceeding the recommended dosage may result in accumulation of the drug with an increased incidence of side effects. **Adults:** The dosage of VIBRAMYCIN I.V. is 200 mg. on the first day of treatment (administered as a single dose or as 100 mg. every 12 hours) followed by a maintenance dose of 100 mg. per day. In the management of more severe infections (particularly chronic infections of the urinary tract), 200 mg. should be given daily throughout the treatment period. Infusion should be carried out at a rate not to exceed 200 mg. over a 30-minute period. Therapy should be continued beyond the time that symptoms and fever subside. **Children:** As yet there is no clinical experience with VIBRAMYCIN I.V. in children. Careful consideration should be given to the risk-benefit ratio in the pediatric age range. Should use be deemed essential, the suggested dosage schedule for children weighing 100 lb. or less is 2 mg./lb. of bodyweight administered as a single or divided dose on the first day of treatment, followed by 1 mg./lb. of bodyweight given as a single or divided dose on subsequent days. For more severe infections, up to 2 mg./lb. of bodyweight may be considered. For children over 100 lb. the usual adult dose may be used. Oral VIBRAMYCIN dosage forms should be administered for continuing therapy as soon as the patient is able to accept oral medication. Therapy should be continued for at least 24-48 hours after symptoms and fever have subsided. Intravenous solutions should be injected directly into the vein. They should not be injected intramuscularly or subcutaneously. Caution should be taken to avoid the inadvertent introduction of the intravenous solution into the adjacent soft tissues.

DOSEAGE FORMS VIBRAMYCIN CAPSULES are available as 100 mg. (blue) hard gelatin capsules containing doxycycline hyclate equivalent to 100 mg. of doxycycline, supplied in bottles of 200, 50 and 20. VIBRAMYCIN FOR ORAL SUSPENSION (doxycycline monohydrate) is available as a dry powder for oral suspension containing, when reconstituted, doxycycline monohydrate equivalent to 25 mg. of doxycycline/5 ml. (each teaspoonful) with a pleasant raspberry flavor in 50 ml. bottles. VIBRAMYCIN I.V. is available as a sterile powder in a vial containing doxycycline hyclate equivalent to 100 mg. of doxycycline with 480 mg. of ascorbic acid. Product Monograph available on request.



PHARMACEUTICAL DIVISION

Montreal

Canada

have the victim's skull, they can do a comparison with the photograph, as described and illustrated on page 397, although this not at present a widely-used technique because it is so time-consuming. Hillsdon Smith estimates it takes about 12 hours of actual work for the photographer to produce a picture of the skull at the proper angle.

The centre now has equipment, however, that can speed up the process considerably. By combining the images from video cameras of the skull and the photograph of the head through a mixing box, and projecting the results on a TV monitor, the skull can be identified as the person in the photograph, or not, within 30 minutes. For record and court purposes the process is repeated using still cameras and translucent printing paper. This technique requires skilled technology, which is forthcoming at the Grenville Street building from photographer Frank Piredda.

Another area of importance for the forensic pathologist is in matching weapons to wounds. "The evidential value of such matching in court varies from being able to state that 'this wound is consistent with this weapon' to 'features on this weapon are faithfully reproduced on the body of the victim'. The latter statement obviously has more evidentiary value than the former," says Hillsdon Smith.

In one case, following the death of a victim, the limbs were cut off the body. A portion of cartilage found in the hip socket which could be fitted into a defect in the head of the corresponding femur had parallel v-shaped grooves. It was possible accurately to match these, three dimensionally, to one of seven knives brought in as possible instruments by the police, as illustrated opposite.

Patterns of injuries form another important area which can help identify the weapon used, the person responsible for the injury or both. In another case, the victim's body had several apparent bite marks on the abdomen. However, the true nature of these marks was revealed by examining the neck area where one complete and two incomplete detailed heel marks were evident. The abdominal injuries were tangentially inflicted kicks by the heel of a shoe. This case is illustrated on page 398.

As well, fabric patterns can be matched on the victim's body to pieces of cloth located elsewhere. In another case, the fabric patterns on the back of a victim's leg were matched to material found on the bumper of a car. "You've got to know what you are looking for," says Ferris. "But I believe

you can find trace evidence in every case if you look for it, and it is important to recognize and record it."

Ferris defines trace evidence as an exchange between two people. "Whenever two people are in physical contact, there is always an exchange between them — saliva, sweat, hairs, semen, clothing fabric. I feel it's up to you to explain you have looked for the evidence and give reasons if you have not found it. There may well be a good reason — the techniques available were not appropriate, the evidence was too small or it was just not there. But you have got to look for it."

The pathologist's testimony, presented in court, could have a decisive influence on the jury. "An important rule of ours," says Ferris, "is to help the police interpret the medical findings and the terminologies. If you can't make the policemen understand what you're saying, what chance have you in court?"

The medical terminology should be explained in layman's terms, he cautions. "If you use particular terms they ought to be easily understood and easily definable. You should not call a wound an incision unless it has been made with a sharp instrument, like a razor blade, and most cuts are not actually cuts but lacerations."

The choice of words can also affect the jury's attitude. "Incised wound," explains Ferris, "almost by definition implies there was intent — but the generic term 'cut' is interpreted by a lay jury as implying accident."

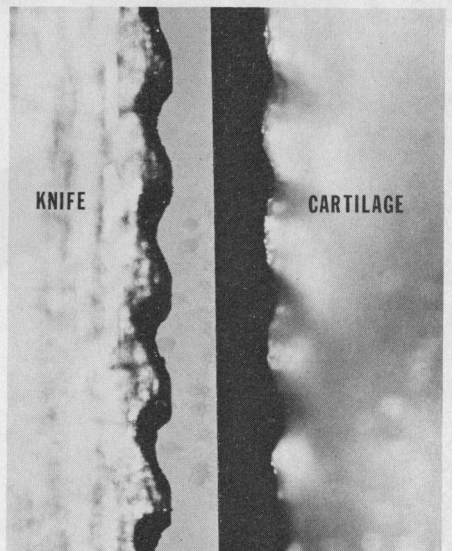
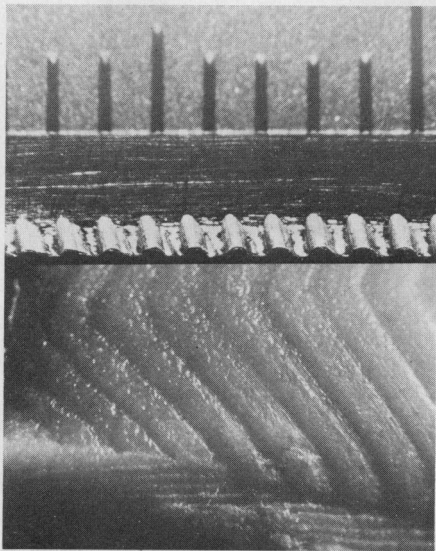
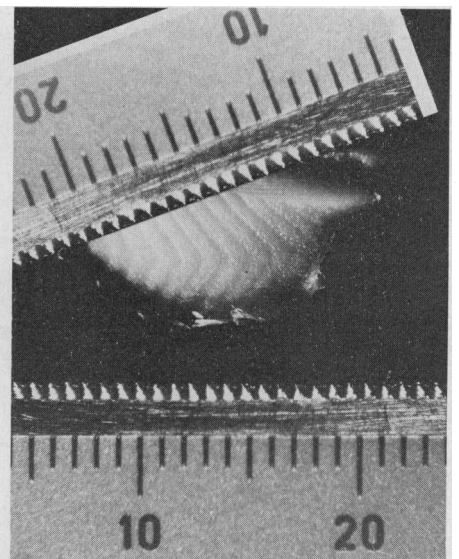
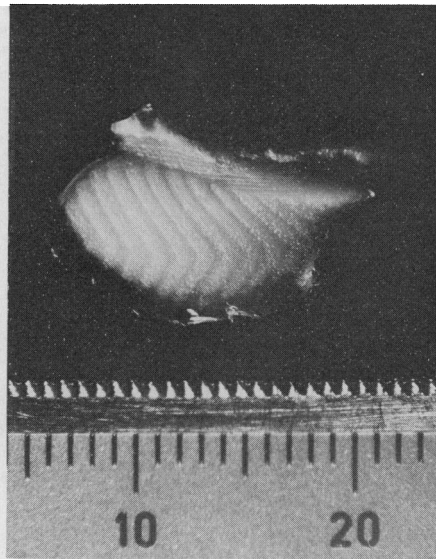
Ferris cites other examples where language can have a powerful effect. The term bleeding should be used instead of hemorrhaging because the latter has an emotive quality to the layman. Instead of "coronary arteries", for the sake of clarity, use "coronary arteries of the heart".

"The language has to be understandable to the doctor and the layman. You don't have to write it for a man with an IQ of 60, but it is for laymen. We also avoid using medical terms that are so complex even doctors have difficulty understanding them."

The pathologist is a professional witness, and his testimony is of increasing value to the courts. "The day of the open-and-shut case due to a confession is going," says Ferris. "They know we all live in a scientific world and they expect to get scientific evidence in courts."

Because of this expanding role, the research now being done will help improve the kind of service forensic pathologists can provide the coroners and the police.

Dr. Hillsdon Smith describes research in this field as "essentially parasitic". "We use anyone else's techniques —



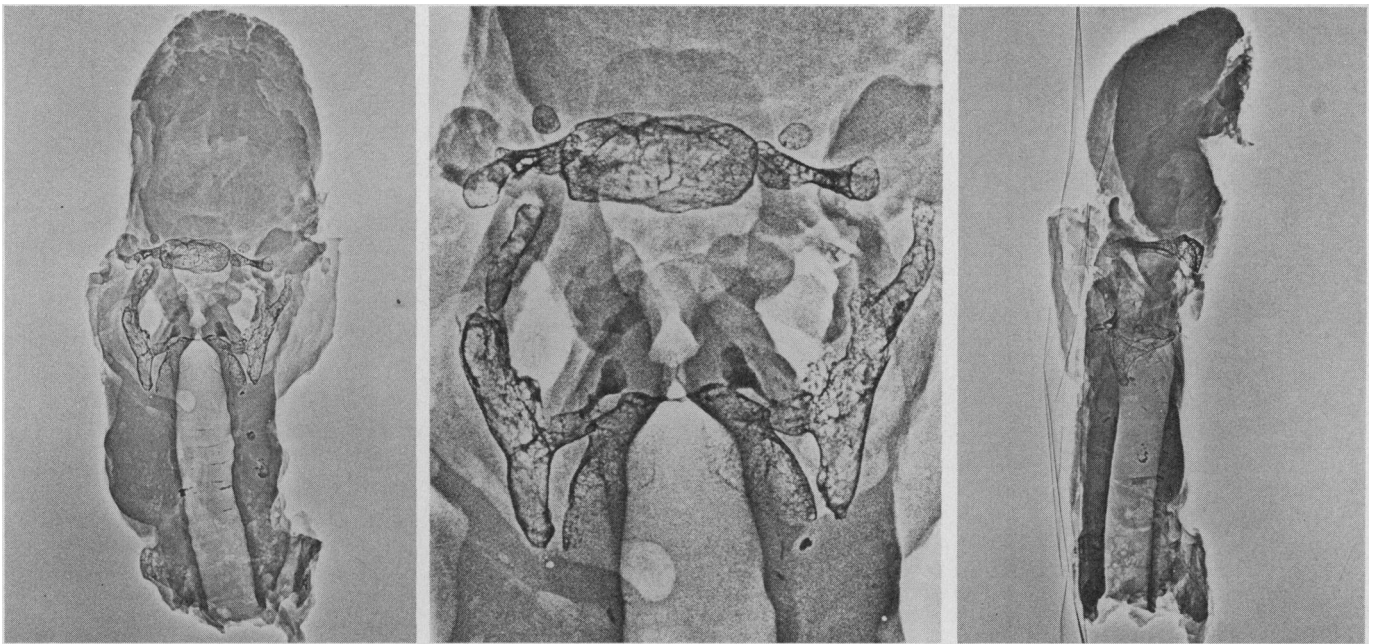
The body of a middleaged woman was found minus the legs, the latter having been disarticulated through the hip joints. At autopsy on the torso a small flake of articular cartilage was found loose in the right hip joint. This flake bore v-shaped parallel grooves on its undersurface. When the legs were later found, they showed a defect in the head of the right femur, into which the flake of cartilage fitted perfectly. On the basis that these marks were produced during disarticulation by a serrated edged knife, seven knives found at the scene were examined. Six were excluded. Photo top left shows cartilage and knife; top right, the marks and the knife-edge are matched. Photo lower left is enlargement of profile view of knife and cartilage, and lower right is comparison microphotograph of knife-edge and cartilage.

in the fields of basic research, applied science and criminalistics. If any technique presents itself which we feel might be useful, we see if we can use it." He says it would be impossible to research the whole field in depth because sophisticated equipment is required, research staff needs to be hired and the cost would be astronomical for what is really a service commitment.

Jim Beaton, a forensic radiographer at the department, says several radiographic procedures have been used to develop improved identification methods as well as for other applications. They are now doing research on gunpowder tattooing — the patterns

created by gunpowder on skin and clothing. When a gun is fired, the powder that is not burned settles in specific patterns on the skin or in material. "The spread of this powder around the bullet is related to the distance at which the gun was fired," adds Hillsdon Smith. "We do xeroradiography to show the pattern on the cloth, and the results so far have been encouraging."

He explains more: "Xeroradiography has a higher radiation level, so there would be some danger if used extensively on living subjects, but this is no problem in forensic pathology. It does reveal far better bony trabecular detail; it enables both soft and hard tissue to be visualised on one film and does not



Xeroradiography of bone permits visualization of fine bony trabecular detail. It has many other forensic uses, as for instance, excellent demonstration of the hyoid bone — important in cases of manual strangulation. Above are an illustration of the hyoid bone, magnification by photography and a lateral view.

require a battery of viewing boxes if presented as evidence in a court of law.

By examining bullets through xeroradiography, it is possible to determine, without opening the bullet, the kind of ammunition used and whether it was commercially or home loaded.

Stereoradiography is another technique being developed. With the use of special viewing glasses and x-rays taken from two angles, bullets or other foreign objects can be accurately located in the body before an autopsy. The body can first be screened by a fluoroscope, an x-ray machine that projects continuous images on a television screen. If it is known in advance whether there are projectiles in the body, they can, by stereoradiography, be recovered during the autopsy without being damaged in the process.

"If they are marked (for example, scratched by forceps) that could confuse the firearms examiner and preclude a conclusion being offered," explains Hillsdon Smith.

"Normally we can recover bullets quite quickly. But if one is lodged in the muscles of the small of the back and the victim is on his back, we have difficulties with the conventional and posteroanterior and lateral views — hence the value of stereoradiography." Because each piece of evidence is important to the outcome of the police investigation and the trial, this is an important problem to overcome.

There is no formal training in forensic pathology in Canada. Hillsdon Smith received his BSc and MD from Birmingham (England) in 1952 and was a consultant in forensic pathology

and a government pathologist in Lusaka to the Northern Rhodesia government from 1960 to 1964. He served as a lecturer in forensic medicine for the University of Edinburgh and as police surgeon to the southeast of Scotland from 1966 to 1973, when he assumed his present position.

Ferris also received his training in Britain. A graduate of Queen's University in Belfast, he lectured in forensic pathology at the University of Newcastle upon Tyne, England, and was a consultant pathologist to the Home Office for the northeast of England from 1970 to 1975.

The forensic pathology agency offers two courses a year, because part of its mandate is to provide instruction in the field. One, held each fall for 8 or 9 days, is a homicide investigation course for experienced detective officers from police forces across Canada. Speakers are recruited from Canada, Britain and the US, and the course is attended by about 100 people.

The second course, which lasts from 4 to 5 days in March, is attended by identification officers from the police forces in Ontario, as well as residents in pathology from the five Ontario medical universities. The remainder of those attending are certified pathologists. Hillsdon Smith says there is a 50-50 mix of police officers and pathologists in the course.

In the US specific requirements must be met to become a certified forensic pathologist, but in Canada there are no formal arrangements in the field. Hillsdon Smith suggests the best way, at present, to gain knowledge of foren-

sic pathology is to specialize in anatomical pathology and then study at certain centres in the US.

Ferris says he feels every anatomical pathologist has "the potential" to provide a forensic medicine service. "It requires an interest in legal matters and requires knowledge of the scope available in the field.

"He's got to be exposed to the experience initially and that exposure should be supervised. He also has to have the ability to communicate with the general public — police, the court and juries in particular. I used to think this (the public speaking aspect) could be taught but now I'm not so sure.

"It is also important to stress the forensic pathologist cannot function in isolation from his hospital pathologist colleague. The hospital pathologist is expert in the diagnosis of disease whereas the forensic pathologist tends to lose that because he tends to deal with relatively healthy people who have suffered a traumatic death."

What's the lure of work of this nature?

Hillsdon Smith isn't sure why it attracts him, but he says he has been interested in it since school and adds that he is probably a "frustrated policeman".

"No two cases are alike. The background stories are all interesting and I like the medical detective type of work. I find I tend to use all my experience and training for it."

CMAJ acknowledges with thanks the help of Dr. John Hillsdon Smith and his colleagues in supplying the illustrations used and reviewing the article.