# IDENTIFICATION GUIDE FOR IVORY AND IVORY SUBSTITUTES

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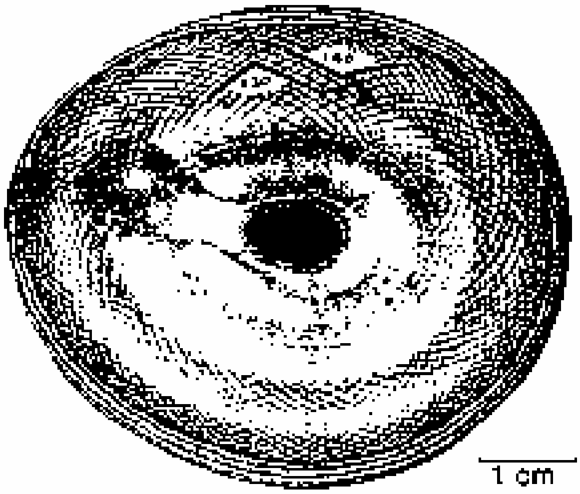


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# Ivory identification: Introduction

TABLE OF CONTENTS



*COVER: An enhanced photocopy of the Schreger pattern in a cross-section of extant elephant ivory. A concave angle and a convex angle have been marked and the angle measurements are shown. For an explanation of the Schreger pattern and the method for measuring and interpreting Schreger angles, see pages 9 – 10.*

## INTRODUCTION

The methods, data and background information on ivory identification compiled in this handbook are the result of forensic research conducted by the United States National Fish & Wildlife Forensics Laboratory, located in Ashland, Oregon.

The goal of the research was to develop a visual and non-destructive means of tentatively distinguishing clearly legal ivory from suspected illegal ivory at ports of entry. As such, it was necessary that the methods be 1) simple to perform, and 2) not to require the use of sophisticated scientific instruments. In this regard, we were successful.

In reviewing the text, you will notice that we did not include detailed classical morphology data on whole tusks or teeth; mostly because the whole structures are fairly easy to identify but also because it is impossible to anticipate which portion of a tusk or tooth will be used for any specific carving. Instead, we chose to focus our attention on the ‘species determining’ characteristics of the ivory material itself.

The result is a handbook designed to offer wildlife law enforcement officers, scientists and managers a tentative visual means of distinguishing legal from illegal ivory, and a “probable cause” justification for seizure of the suspected illegal material.

One point which must be emphasized: while the methods described in this handbook are reliable for the purposes described (i.e.: tentative visual identification, and “probable cause” to seize as evidence), *an examination of the carved ivory object by a trained scientist is still necessary to obtain a positive identification of the species source.*

We hope that this handbook proves to be useful to you in your endeavors to protect ivory-bearing species.

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The identification guide for ivory and ivory substitutes was published in a form of a booklet in 1991. It was published in the three working languages of the Convention by World Wildlife Fund and the Conservation Foundation.

Because the booklet was sold out, the Secretariat has decided to reprint the text and the illustrations as part of the CITES Identification Manual.

The Secretariat is grateful to World Wildlife Fund and the Conservation Foundation for permitting this reprint, and to the authors for verifying the original text, that needed no amendments.

## WHAT IS IVORY?

The word “ivory was traditionally applied only to the tusks of elephants. However, the chemical structure of the teeth and tusks of mammals is the same regardless of the species of origin, and the trade in certain teeth and tusks other than elephant is well established and widespread. Therefore, “ivory” can correctly be used to describe any mammalian tooth or tusk of commercial interest which is large enough to be carved or scrimshawed.

Teeth and tusks have the same origins. Teeth are specialized structures adapted for food mastication. Tusks, which are extremely large teeth projecting beyond the lips, have evolved from teeth and give certain species an evolutionary advantage. The teeth of most mammals consist of a root, a neck and a crown. A tusk consists of a root and the tusk proper.

Teeth and tusks (Fig. 8) have the same physical structures: pulp cavity, dentine, cementum and enamel. The innermost area is the pulp cavity. The pulp cavity is an empty space within the tooth that conforms to the shape of the pulp.

Odontoblastic cells line the pulp cavity and are responsible for the production of dentine. Dentine, which is the main component of carved ivory objects, forms a layer of consistent thickness around the pulp cavity and comprises the bulk of the tooth and the tusk. Dentine is a mineralized connective tissue with an organic matrix of collagenous proteins. The inorganic component of dentine consists of dahllite with the general formula $Ca_{10}(PO_4)_6(CO_3)\ H_2O$. Dentine contains a microscopic structure called dentinal tubules which are micro-canals that radiate outward through the dentine from the pulp cavity to the exterior cementum border. These canals have different configurations in different ivories and their diameter ranges between 0.8 and 2.2 microns. Their length is dictated by the radius of the tusk. The three dimensional configuration of the dentinal tubules is under genetic control and is therefore a characteristic unique to the order.

Exterior to the dentine lies the cementum layer. Cementum forms a layer surrounding the dentine of tooth and tusk roots. Its main function is to adhere the tooth and tusk root to the mandibular and maxillary jaw bones. Incremental lines are commonly seen in cementum.

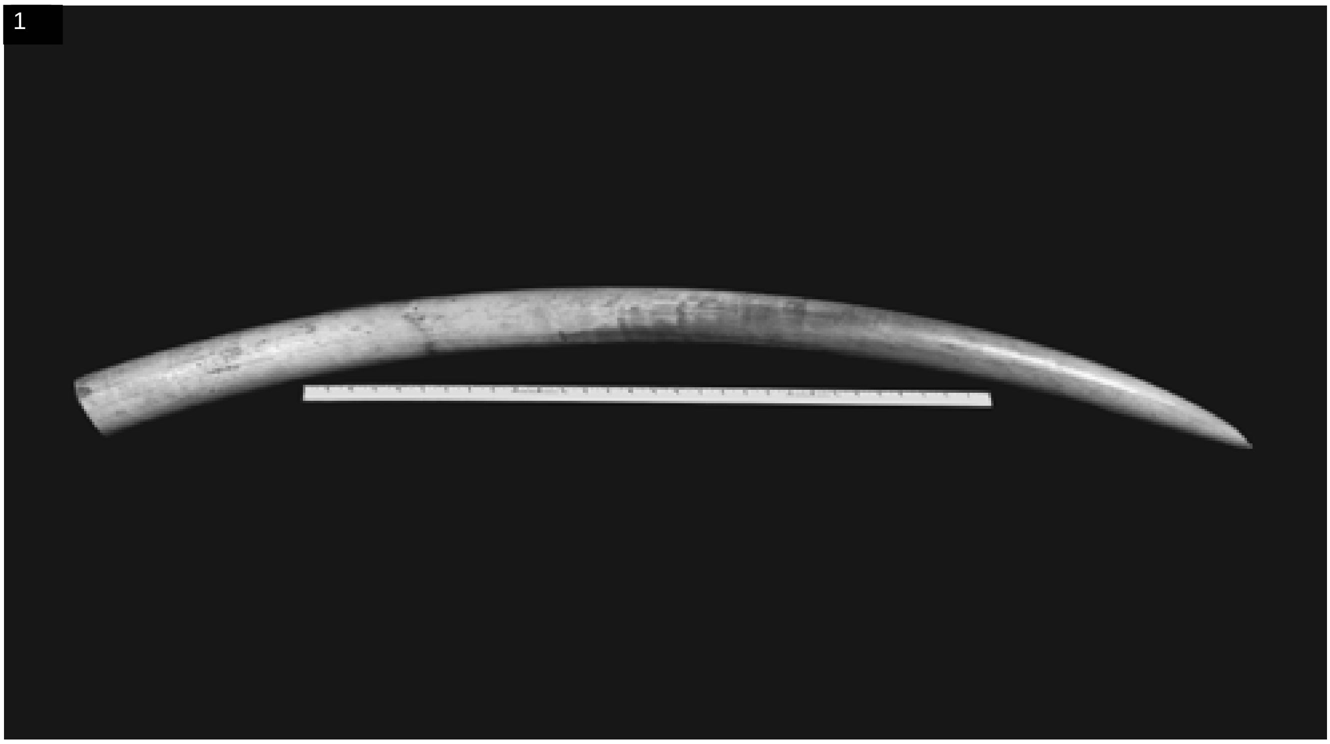
Enamel, the hardest animal tissue, covers the surface of the tooth or tusk which receives the most wear, such as the tip or crown. Ameloblasts are responsible for the formation of enamel exhibits a prismatic structure with prisms that run perpendicular to the crown or tip. Enamel prism patterns can have both taxonomic and evolutionary significance.

Tooth and tusk ivory can be carved into an almost infinite variety of shapes and objects. A few examples of carved ivory objects are small statuary, netsukes, jewelry, flatware handles, furniture inlays, and piano keys. Additionally, wart hog tusks, and teeth from sperm whales, killer whales and hippos can also be scrimshawed or superficially carved, thus retaining their original shapes as morphologically rocognizable objects.

The identification of ivory and ivory substitutes is based on the physical and chemical class characteristics of these materials. This handbook presents an approach to identification using the macroscopic and microscopic Physical characteristics of ivory in combination with a simple chemical test using ultraviolet light. Table 1, to be used in conjunction with the text of this handbook, is a suggested flow chart for the preliminary identification of ivory and ivory substitutes. Table 2 summarizes the class characteristics of selected commercial ivories. Table 3 and 4 summarize the class characteristics of selected ivory substitutes. Appendix 1 is a step-by-step guide for identification using this text. Appendix 2 is a list of supplies and equipment for use in the preliminary identification of ivory and ivory substitutes.

**PLATE 1**

## NATURAL UNPROCESSED IVORY

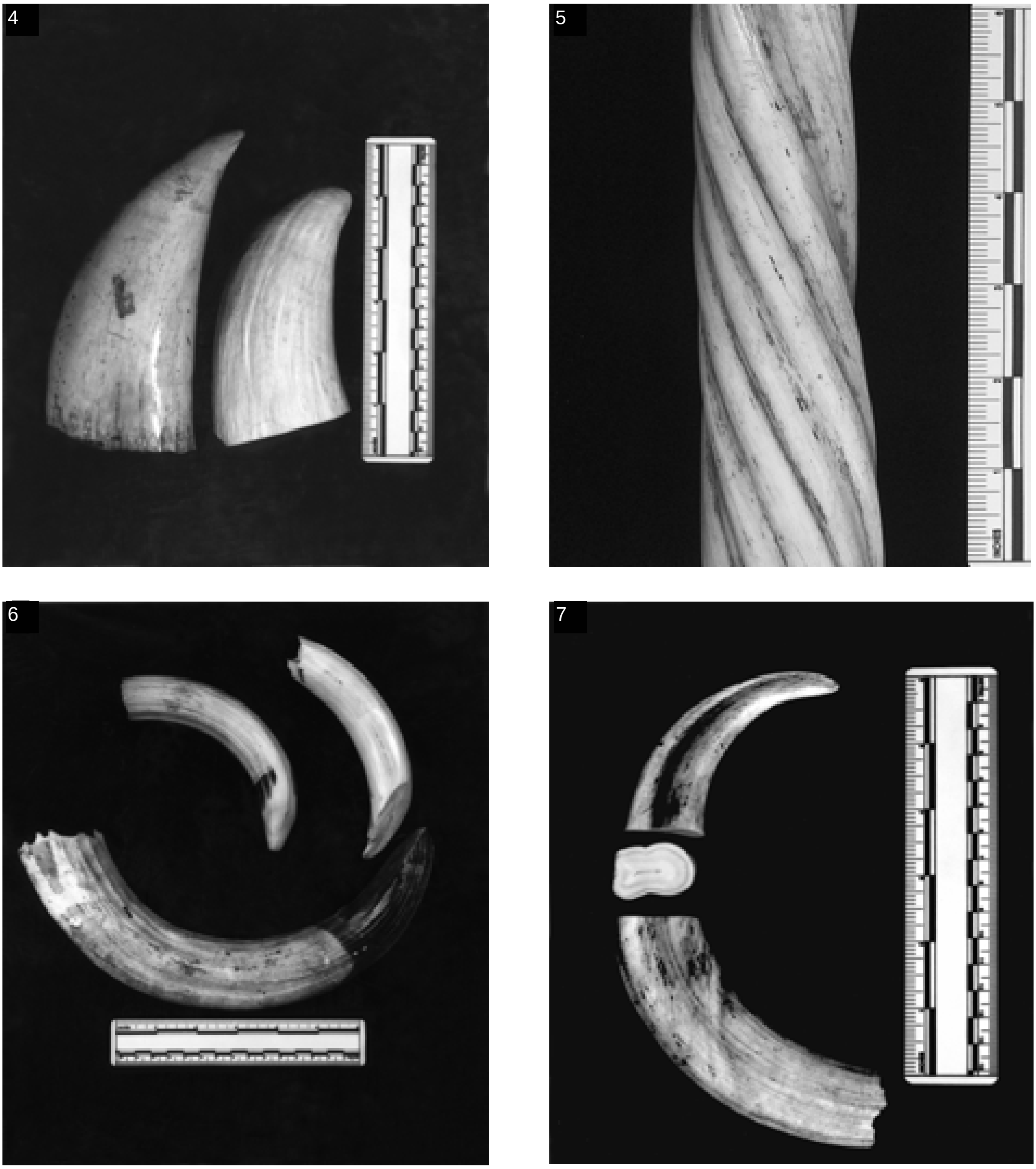





1. African elephant tusk (upper incisor); 2. Walrus tusk (upper canine); 3. Walrus teeth.

**PLATE 2**

**NATURAL UNPROCESSED IVORY**



4. Whale teeth (Sperm/Killer whales); 5. Narwhal (upper incisor) Note: this tusk has been partly worked; 6. Hippopotamus teeth (clockwise from top left: upper incisor, upper canine, lower canine); 7. Wart hog tusk (upper canine).

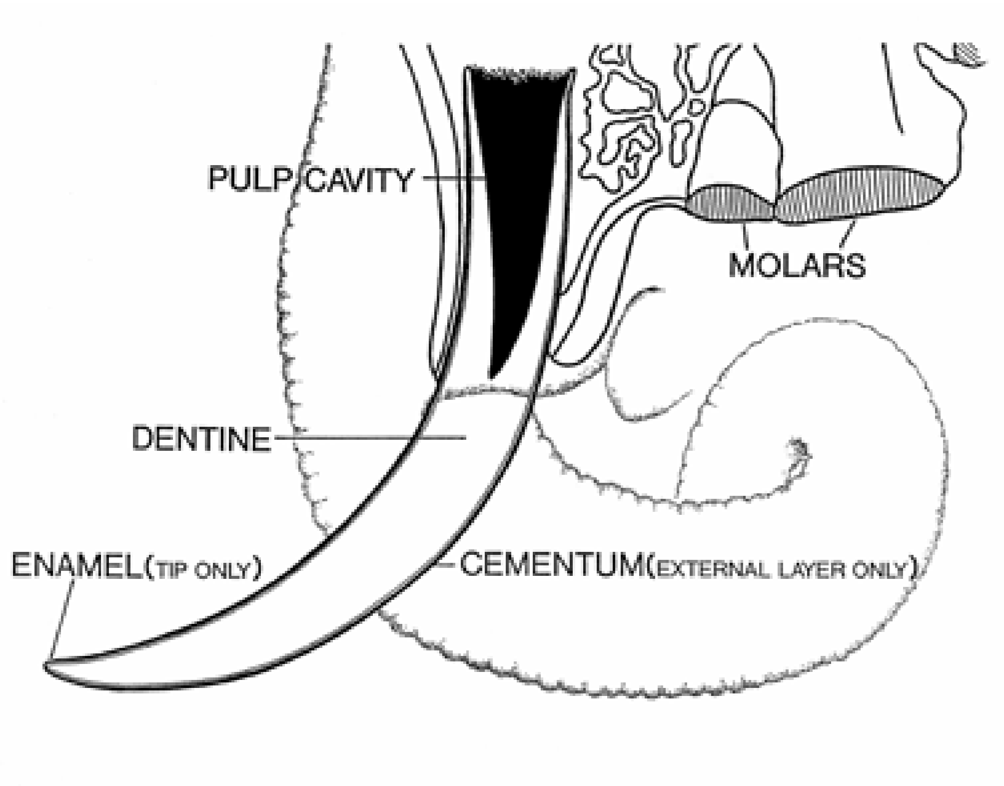
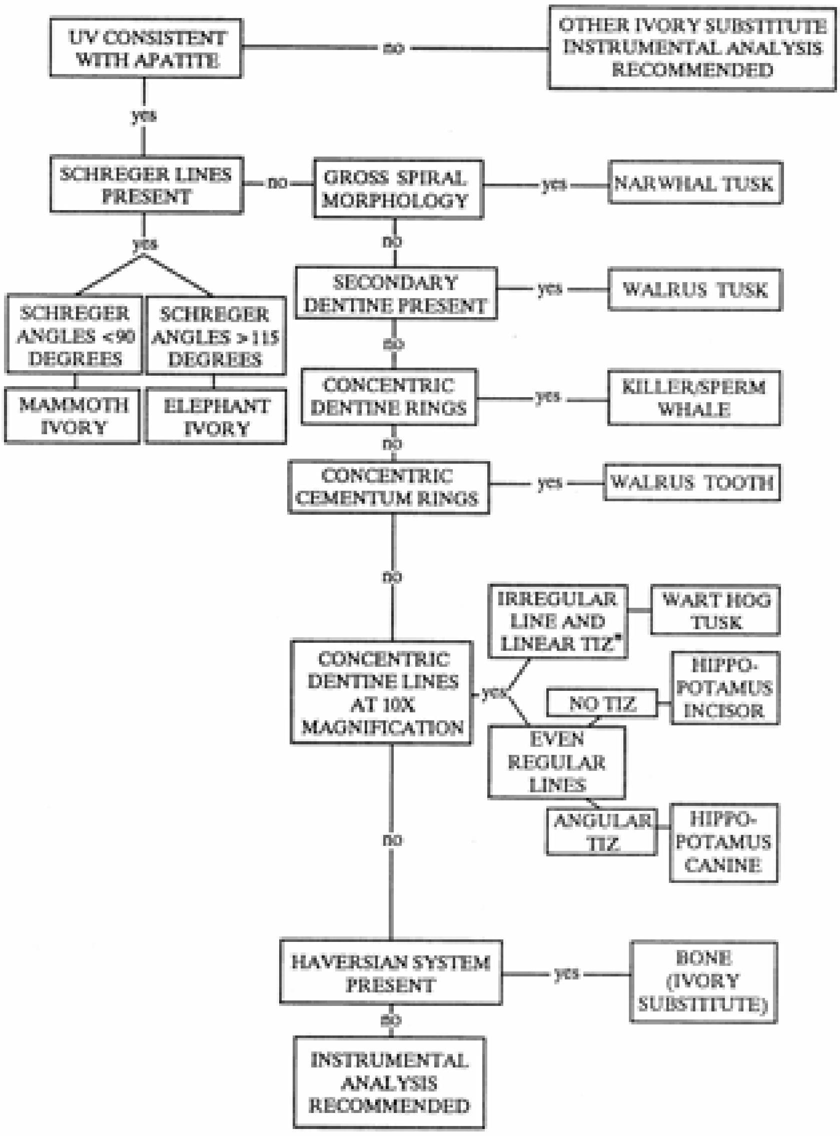



Figure 8. Diagram of tusk morphology.

## TABLE 1. SCHEME FOR THE PRELIMINARY CHARACTERIZATION OF IVORY AND IVORY SUBSTITUTES IN CROSS-SECTION




*TIZ = Tusk Interstitial Zone

## TABLE 2. CLASS CHARACTERISTICS OF SELECTED COMMERCIAL IVORIES

| SOURCE | MODIFIED TOOTH | MACROSCOPIC CHARACTERISTIC | MICROSCOPIC CHARACTERISTIC (10X) | ENAMEL | UV CHARAC-TERISTIC |
|---|---|---|---|---|---|
| Elephant (Asian and African) | upper incisors | Schreger angles> 115 degrees in cross-section | | tip, worn away | |
| Mammoth | upper incisors | Schreger angles < 90 degrees in cross-section | | | vivianite may be present |
| Walrus tusk | upper canines | secondary dentine in cross-section | | tip, worn away | |
| Walrus teeth | all teeth | cementum rings in cross-section; hypercementosis | | tip, may be worn | |
| Killer/Sperm Whale | all teeth | dentine rings in cross-section | | tip | |
| Narwhal | upper incisor | spiral; hollow center in cross-section | | tip, worn away | |
| Hippopotamu s | upper canines | oval cross-section angular TIZ | fine concentric lines in cross-section | longitudinal band | |
| Hippopotamu s | lower canines | triangular cross-section; angular TIZ | fine concentric lines in cross-section | longitudinal band | |
| Hippopotamu s | lower incisors | peg-shaped; no TIZ (dot) | fine concentric lines in cross-section | tip | |
| Wart Hog | upper and lower canines | squared cross-section; linear TIZ | fine concentric lines in cross-section | longitudinal band | |

**ELEPHANT AND MAMMOTH** *(Laxodonta africana, Elephas maximus, Mammuthus)*

Elephant and mammoth tusk ivory comes from the two modified upper incisors of extant and extinct members of the same order (Proboscidea). African and Asian elephants are both extant. Mammoths have been extinct for 10,000 years. Because of the geographical range in Alaska and Siberia, *Mammuthus primigenus* tusks have been well preserved. Therefore, *Mammuthus primigenus* is the only extinct proboscidean which consistently provides high quality, carvable ivory.

An African elephant tusk can grow to 3.5 meters in length. Enamel is only present on the tusk tip in young animals. It is soon worn off and not replaced. Whole cross-section of proboscidean tusks are rounded or oval. Dentine composes 95% of the tusk and will sometimes display broad concentric bands. Cementum, which can be thick in extinct genera, covers the outside of the tusk. Cementum can present a layered appearance, particularly in mammoth.

Polished cross-section of elephant and mammoth ivory dentine display uniquely characteristic Schreger lines.[1] Schreger lines are commonly referred to as cross-hatchings, engine turnings, or stacked chevrons. Schreger lines can be divided into two categories. The easily seen lines which are closest to the cementum are the outer Schreger lines. The faintly discernable lines found around the tusk nerve pulp cavities are the inner Schreger lines. The intersections of Schreger lines form angles. These Schreger angles appear in two forms: concave angles and convex angles. Concave angles have slightly concave sides and open to the medial (inner) area of the tusk. Convex angles have somewhat convex sides and open to the lateral (outer) area of the tusk. Outer Schreger angles, both concave and convex, are acute in extinct proboscidea and obtuse in extant proboscidea (Fig. 9).[1]

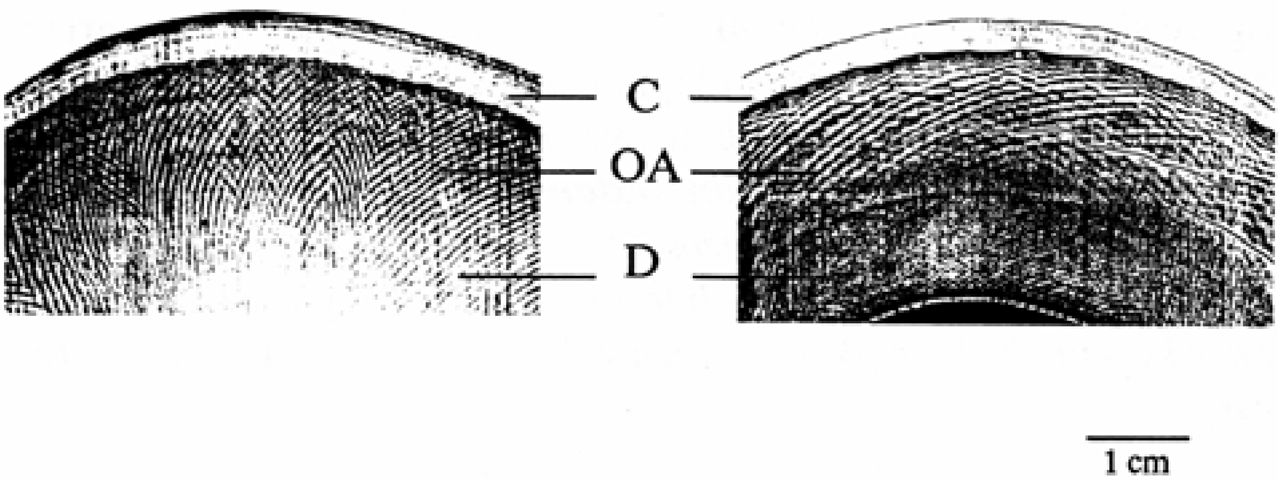



Figure 9. Photocopies of extinct (left) and extant (right) proboscidean ivory cross-sections. The outer Schreger angles (OA) are those which are in the dentine (D) closest to the cementum (C).

A photocopy machine is used to capture Schreger angles from mammoth and elephant ivory cross-sections. The cross-section is placed on the glass plate of a photocopy machine. A blue photocopy

1 *Schreger lines in proboscidean dentine were described by the German anatomist Bernhard Gottlob Schreger in 1800 (Obermayer 1881) and should not be confused with Hunter-Schreger bands in enamel.*

transparency sheet may be placed between the object and the glass plate to enhance the detail of the photocopy. Enlargement of the photocopy may also improve the image and facilitate the measurement process.

After a photocopy of the ivory cross-section has been obtained, Schreger angles may be marked and measured. Use a pen or pencil and a ruler to mark and extend selected outer Schreger angle lines. **NOTE:** ***Only outer Schreger angles should be used in this test***. Once the angles have been marked and extended, a protractor is used to obtain an angle measurement. Several angles, including both concave and convex angles, should be marked and measured. Once the angles have been marked and measured, calculate the angle average. The angle average can then be compared to the data base in Figures 10 and 11.

Figures 10 and 11 show the angle data obtained in the study of the outer Schreger pattern of 26 cross-sections of elephant ivory (*Laxodonta africana* and *Elephas maximus*) and 26 cross-sections of mammoth ivory (*Mammuthus primigenus*). Five concave and five convex angles were measured on each of these 52 samples. The distribution of all 520 of these angles is presented in Figure 10. This figure shows that between 90 degrees and 115 degrees an overlap exists in the lower end of the elephant concave angle range and the upper end of the mammoth concave/convex angle range*.* Because specimens from both extinct and extant sources may present angles between 90 degrees and 115 degrees in the outer Schreger pattern area, the differentiation of mammoth from elephant ivory should never be based upon single angle measurements when the angles fall in this range.

The distribution of the averages (means) of the concave and convex outer angles from the 52 samples of elephant and extinct proboscidean ivory is presented in Figure 11. When the averages are used to represent the angles in the individual samples, a clear separation between extinct and extant proboscideans is observed. All the elephant samples had averages above 100 degrees, and all the extinct proboscideans had angle averages below 100 degrees.

Another feature may be used to identify mammoth ivory. Mammoth ivory will occasionally display intrusive brownish or blue-green colored blemishes caused by an iron phosphate called vivianite. Elephant ivory will not display intrusive vivianite discoloration in its natural state. It is of interest to note that when the discoloration is barely perceptible to the eye, the use of a hand-held ultraviolet light source causes the blemished area to stand out with a dramatic purple velvet-like appearance. Even if discolored, elephant ivory will not have the characteristic fluorescence of vivianite.

Figure 10. Histogram of all outer Schreger angles of extinct and extant proboscidean ivory samples (N = 260 each).

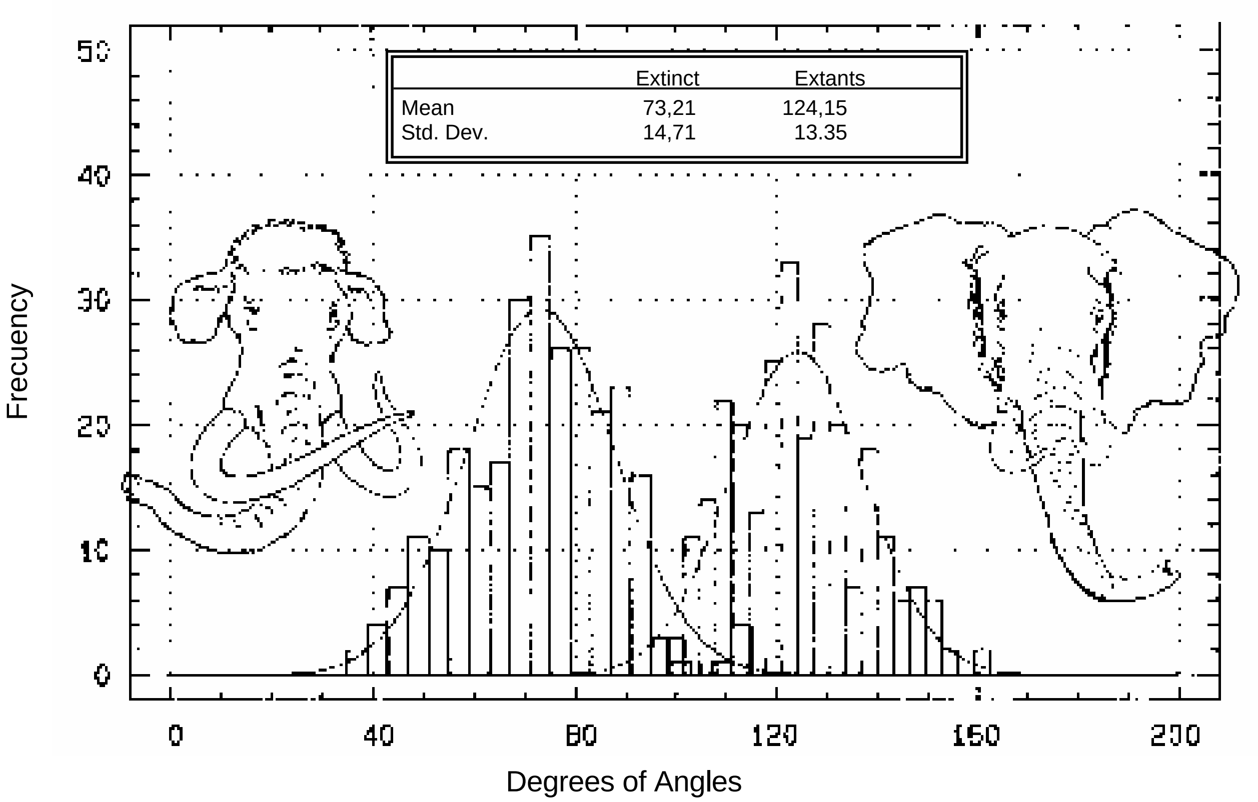
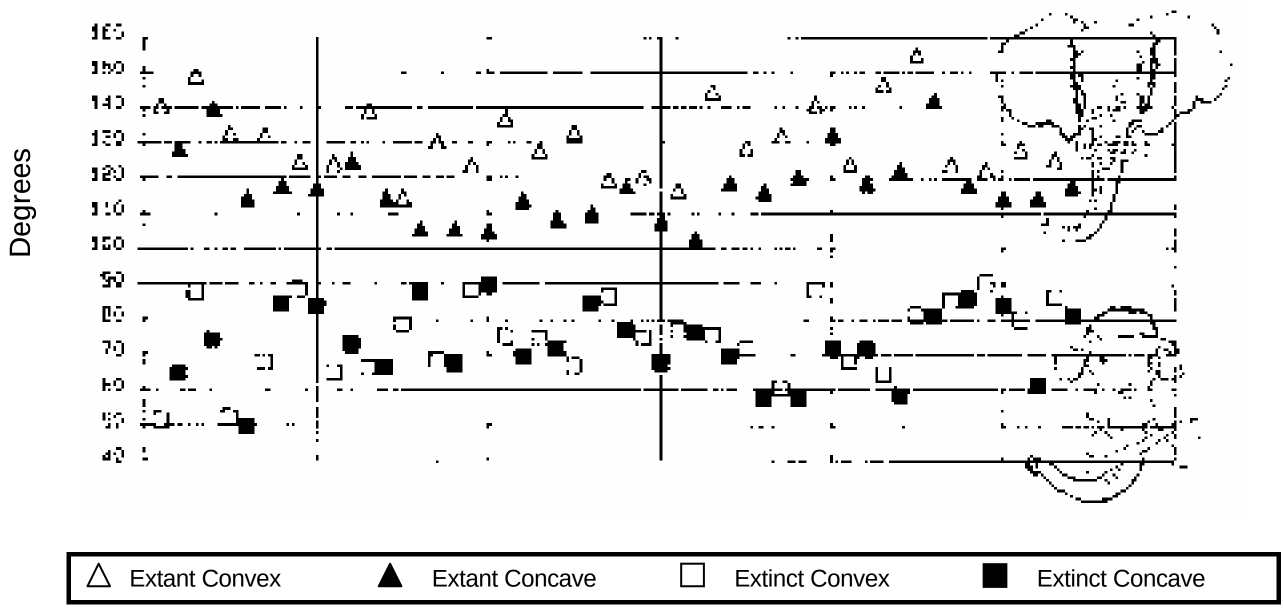



Figure 11. Plot of mean concave and mean convex outer Schreger angles of extinct and extant proboscidean ivory samples (N = 26 each).



**WALRUS** *(Odobenus rosmarus)*

Walrus tusk ivory comes from two modified upper canines. The tusks of a Pacific walrus may attain a length of one meter. Walrus teeth are also commercially carved and traded. The average walrus tooth has a rounded, irregular peg shape and is approximately 5 cm in length.

The tip of a walrus tusk has an enamel coating which is worn away during the animal's youth. Fine longitudinal cracks, which appear as radial cracks in cross-section, originate in the cementum and penetrate the dentine. These cracks can be seen throughout the length of the tusk. Whole cross-sections of walrus tusks are generally oval with widely spaced indentations. The dentine is composed of two types: primary dentine and secondary dentine (often called osteodentine) (Fig. 13). Primary dentine has a classical ivory appearance. Secondary dentine looks marbled or oatmeal-like. This type of secondary dentine is diagnostic for walrus tusk ivory.

The dentine in walrus teeth is mainly primary dentine. The center of the tooth may contain a small core of apparent secondary dentine. The dentine is completely surrounded by a cementum layer. Enamel may or may not be present according to the extent to which the tooth has been carved or worn. A cross-section of a walrus tooth will show very thick cementum with prominent cementum rings (Fig. 12). Concentric rings in walrus teeth are due to hypercementosis. The dentine is separated from the cementum by a clearly defined narrow transition ring.

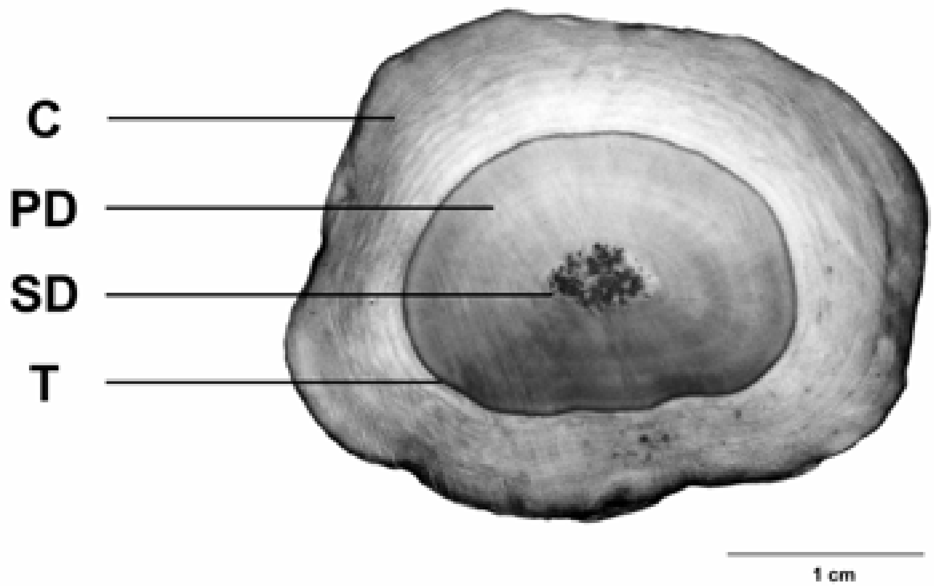



Figure 12. Enlarged and enhanced photograph of a cross-section of a walrus tooth showing cemetum (C), transition ring (T), and primary dentine (PD). This tooth also shows a small area of apparent secondary dentine (SD). Note the presence of concentric rings in the exceptionally thick cementum.

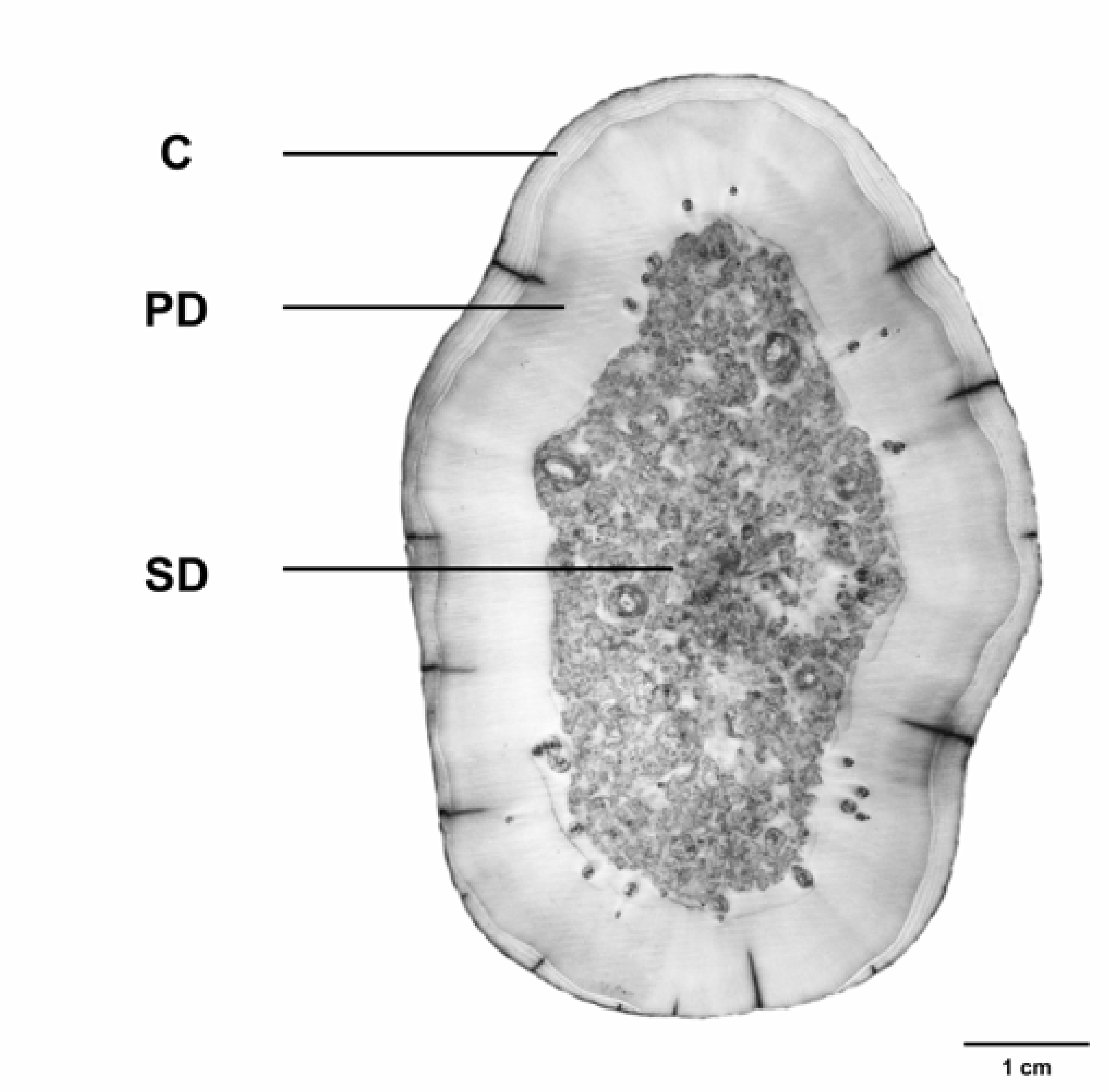



Figure 13. Enlarged and enhanced photograph of a cross-section of walrus tusk showing cementum (C), primary dentine (PD), and secondary dentine (SD).

**SPERM WHALE AND KILLER WHALE** *(Physter catodon* and *Orcinus orca)*

Sperm whale teeth can be quite large. The average height is approximately twenty centimeters. Killer whale teeth are smaller. Both species display conically shaped teeth with a small amount of enamel at the tips. The rest of the tooth is covered by cementum. Whole cross-section of killer whale and sperm whale teeth are rounded or oval (Fig. 14). In addition, killer whale teeth show two slight peripheral indentations. The dentine is deposited in a progressive laminar fashion. As a result of this laminar deposition, killer and sperm whale teeth will show prominent concentric dentine rings in cross-section. Killer whale teeth may also display a faint rosette pattern in the dentine cross-section. The dentine is separated from the cementum by a clearly defined transition ring.

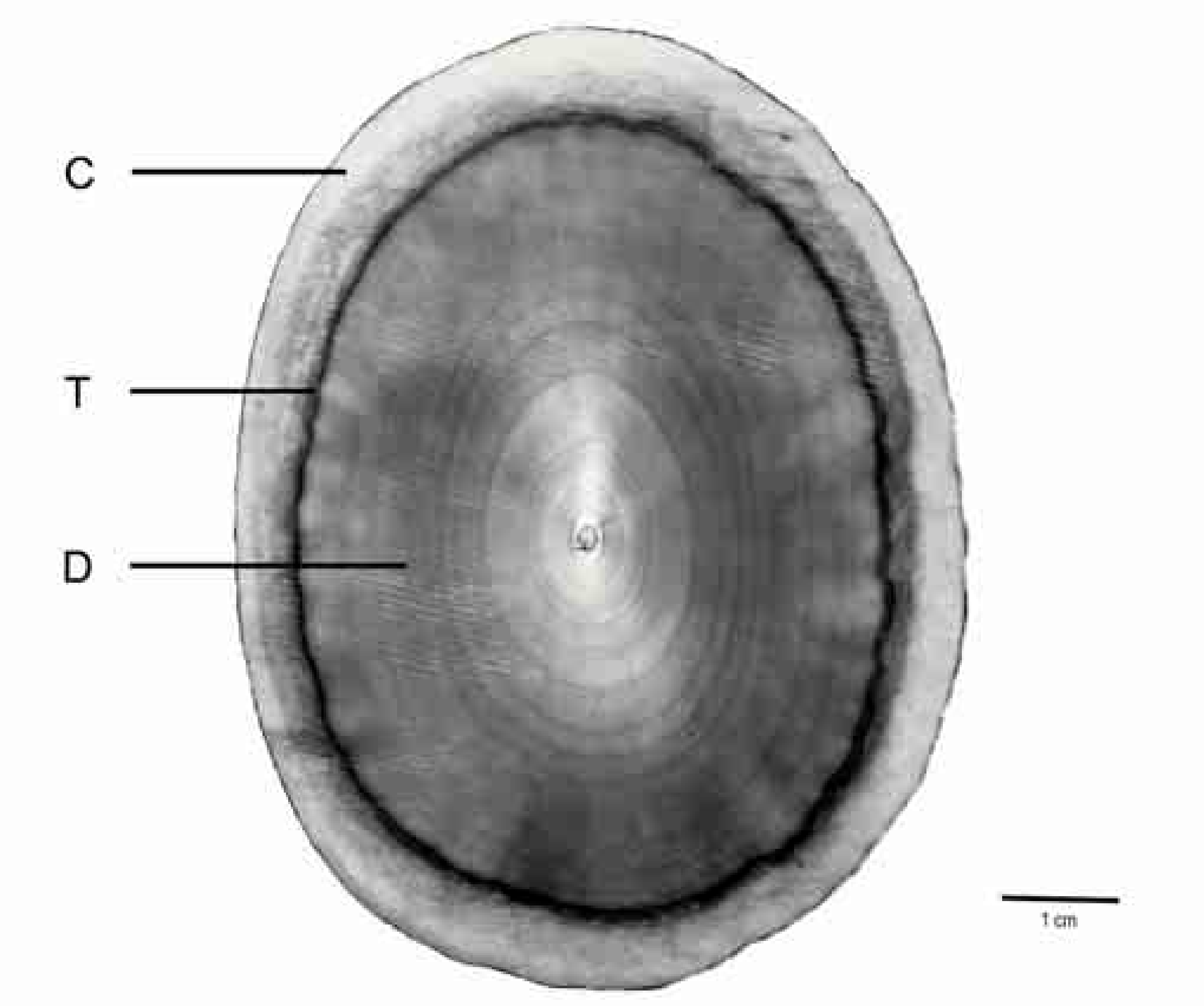



Figure 14. Enlarged and enhanced photograph of a cross-section of a sperm whale tooth showing cementum (C), transition ring (T), and dentine (D). Note the presence of concentric rings in the dentine.

**NARWHAL** *(Monodon monoceros)*

The narwhal is a rarely seen arctic whale. The male of this species has a single left tusk that is a modified upper incisor. The tusk is spirally twisted, usually in a counter-clockwise direction. In a mature specimen the tusk can be from two to seven meters long. Enamel may be present at the tip of the tusk. The cementum frequently displays longitudinal cracks which follow the depressed areas of the spiral pattern. As a result, narwhal tusk cross-sections are rounded with peripheral indentations. The cementum is separated from the dentine by a clearly defined transition ring. Like killer and sperm whale, the dentine can display prominent concentric rings. The pulp cavity extends throughout most of the length of the tusk giving cross-sections a hollow interior (Fig. 15).

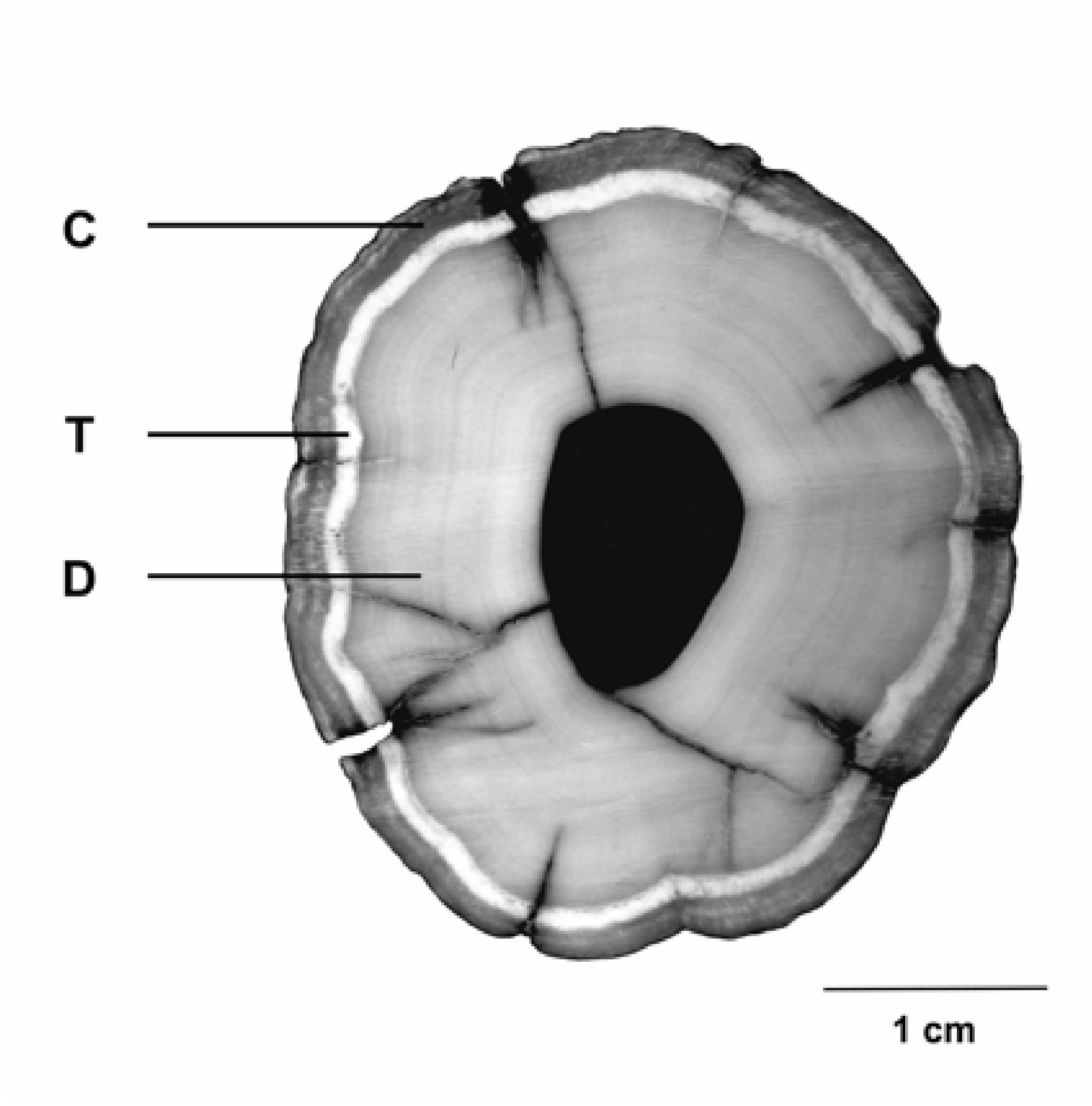



Figure 15. Enlarged and enhanced photograph of a cross-section of narwhal tusk showing the cementum (C), transition ring (T), and dentine (D).

**HIPPOPOTAMUS** *(Hippopotamus amphibius)*

Upper and lower canines and incisors are the most common sources for hippo ivory. Each type of tooth has distinctive gross morphology. Close examination of cross-section of hippo dentine with the aid of a 10X hand lens reveals a tightly packed series of fine concentric lines. These lines can be regularly or irregularly spaced. The orientation of the lines will follow the overall shape of the particular tooth. The center of the tooth may display an interstitial zone (TIZ). This interstitial zone represents the growth convergence of the developing dentin.

The hippo's curved upper canines are oval to rounded in cross-section. In the unprocessed state, a deep longitudinal indentation extends for the length of the tooth on the inner surface of the curve. A broad longitudinal band of enamel covers approximately two-thirds of the surface area of the tooth. This enamel band is frequently removed during the carving process. The surface which is not coated with enamel displays a very thin layer of cementum. This may also be removed during processing. The interstitial zone in the upper canine is a curved line of broadly arched line (Fig. 16).

The lower canines are the hippo's largest teeth. They are strongly curved. In cross-section, the lower canines are triangular. Raw lower canines will display a faint longitudinal indentation, a marked rippling of the surface and an approximate two-thirds coverage with enamel. Like upper canine, a thin layer of cementum exists in the areas not covered with enamel. And, as with the upper canines, these surface characteristics are frequently removed during processing. The interstitial zone in the lower canine is broadly arched line (Fig. 17).

Hippo incisors can be described as peg shaped. Enamel is found on the tooth crown. The center of the tooth in cross-section shows a small dot (Fig. 18).

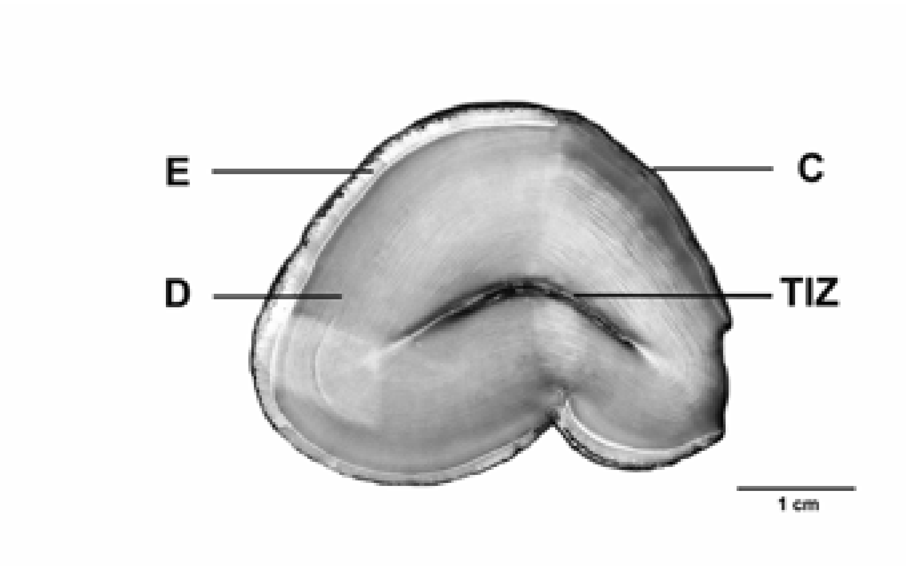



Figure 16. Enlarged and enhanced photograph of a cross-section of hippo upper canine showing cementum (C), enamel (E), and dentine (D). Note the angular tusk interstitial zone (TIZ) and the fine lines in the dentine.

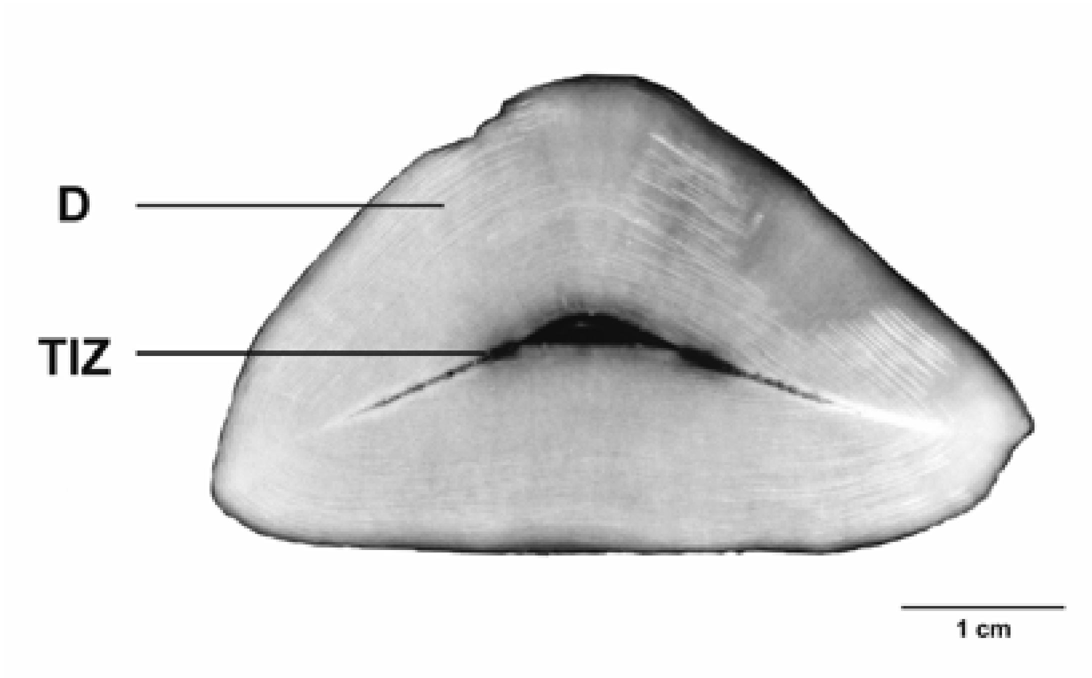



Figure 17. Enlarged and enhanced photograph of a cross-section of hippo lower canine showing dentine (D) only. The cementum has been mechanically removed from this specimen. Note the arched tusk interstitial zone (TIZ) and the fine lines in the dentine.

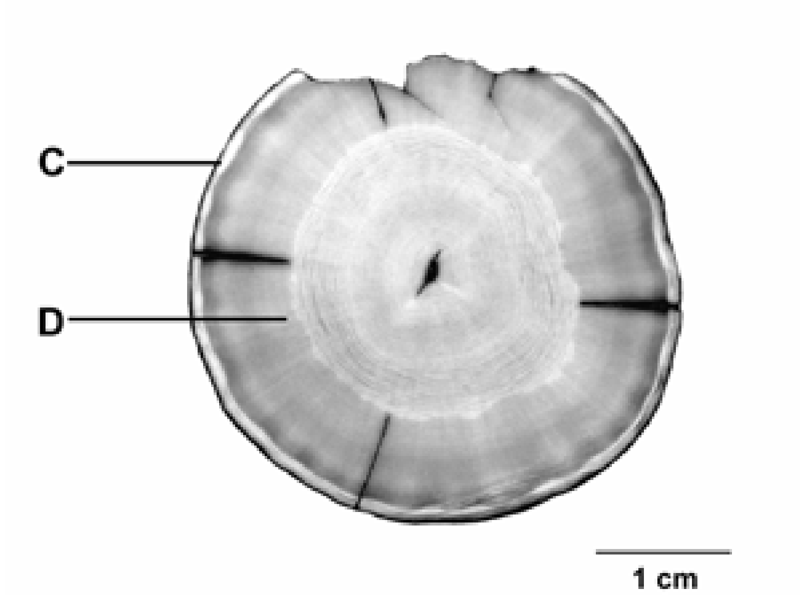



Figure 18. Enlarged and enhanced photograph of a cross-section of hippo incisor showing cementum (C) and dentine (D). Note the fine lines in the dentine.

**WART HOG** *(Phacochoerus aethiopicus)*

Wart hog ivory comes from the animal's upper and lower canine teeth. These tusks are strongly curved and have generally squared cross-sections. Full length to near full length furrows and a longitudinal enamel band with approximately one–half to two-thirds coverage mark the tusks' surface in the raw, unprocessed state. The interstitial zone is a narrow line. Wart hog ivory tends to have a mottled appearance. Examination of a cross-section with a 10X hand lens reveals that wart hog dentine shows irregularly spaced concentric lines of varying thickness (Fig. 19).

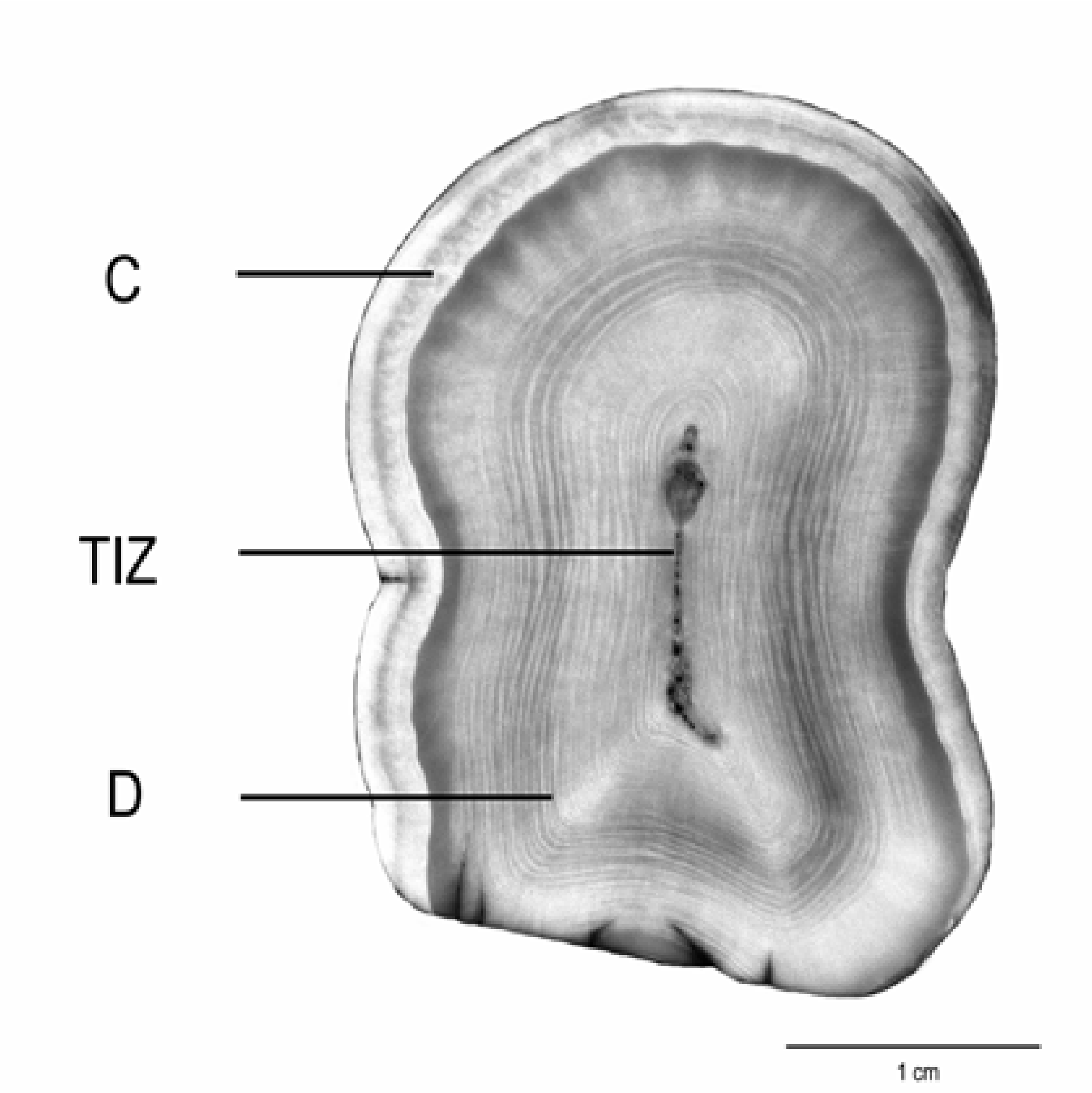



Figure 19. Enlarged and enhanced photograph of a cross-section of a wart hog tusk showing cementum (C) and dentine (D). Note the tusk interstitial zone (TIZ) line and fine lines in the dentine.

## IVORY SUBSTITUTES

There are two categories of ivory substitutes: natural and manufactured. Among the natural ivory substitutes are bone, shell, hornbill ivory, and vegetable ivory. Plastic is a type of manufactured ivory substitute. Ivory substitutes are readily distinguishable from ivory by virtue of their ultraviolet light reactivity in combination with their physical characteristics. Sophisticated laboratory based examinations using non-destructive Fourier Transform Infrared Spectroscopy (FT-IR) will extend the identification process by analyzing the chemical constituents of the ivory substitute. Table 3 summarizes the class characteristics of ivory substitutes.

## TABLE 3. CLASS CHARACTERISTICS OF SELECTED IVORY SUBSTITUTES

| SOURCE | MATERIAL TYPE | MACROSCOPIC CHARACTERISTIC | MICROSCOPIC CHARACTERISTIC | UV CHARACTERISTIC |
|---|---|---|---|---|
| Bone | dahllite | haversian system | | fluorescence like ivory |
| Shell | calcium carbonate | color mottling may be present | | mottled dull blue fluorescence |
| Helmeted Hornbill | keratin | red coloration on periphery | | red color appears blue; ivory color remains true |
| Vegetable ivory | cellulose | dark brown husk may be present | fine concentric lines | fluorescence similar to ivory |
| Manufactured ivory substitutes | casein plus resin | | | absorbs UV light; dull blue appearance; celluloid may appear “mocha” |
| Manufactured ivory substitutes | ivory dust plus resin | | | absorbs UV light; dull blue appearance; |
| Manufactured ivory substitutes | polyester or phenolic resins | | | absorbs UV light; dull blue appearance; |

## NATURAL IVORY SUBSTITUTES

### Bone

Bone is a mineralized connective tissue consisting of dahllite, proteins and lipids. Compact bone, which is most often used as an ivory substitute, is extensively permeated by a series of canals through which fluid flows. This is the Haversian System. The Haversian canals can be seen on a polished bone surface using a 10X hand lens. These canals appear as pits or scratch-like irregularities (Fig. 20). Their appearance is often accentuated by the presence of discolored organic material which adheres to the pit walls.

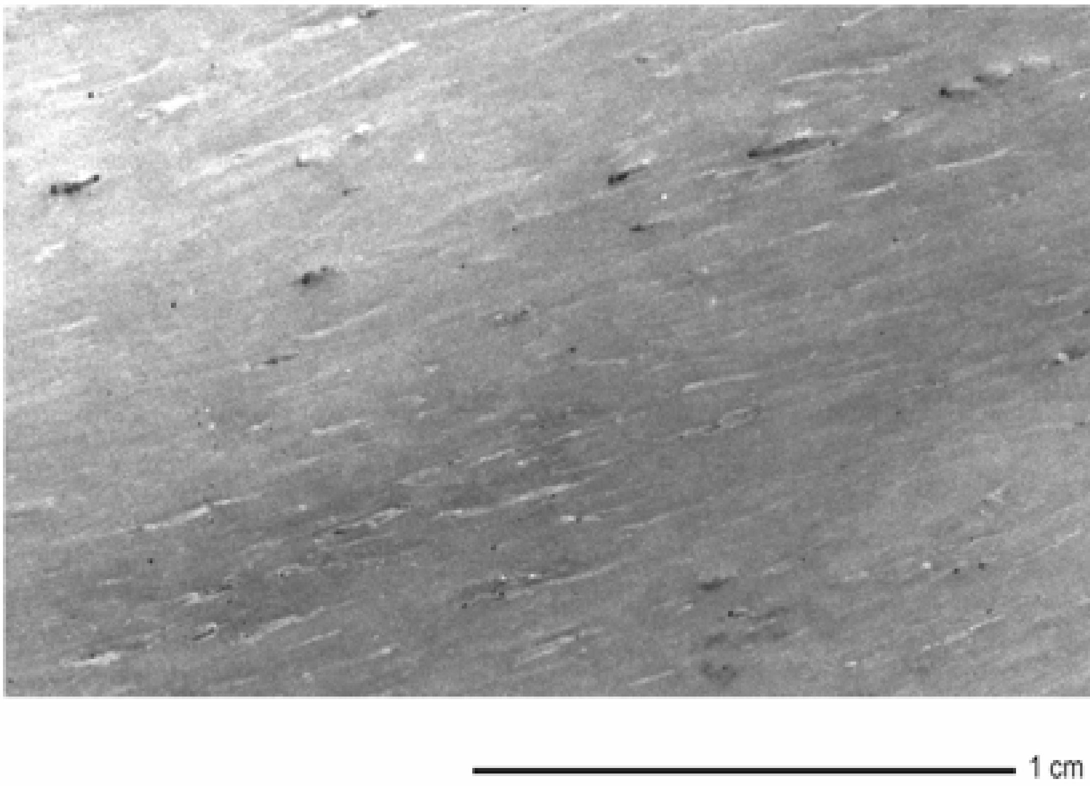



Figure 20. Photomicrograph of bone. Note the Haversian and irregularities on the surface.

### Shell

Shell is a calcium carbonate found as the protective covering of a soft bodied mollusk. Shell can be polished to a very smooth hard surface. Shells may present color mottling which persists through ultraviolet examination. In the absence of gross morphological features, identification of shell is best done by FT-IR.

### Helmeted Hornbill *(Rhinoplax vigil)*

The casque of the endangered Helmeted Hornbill (Fig. 21), a native of Borneo, can be carved and polished. The casque is a hollow, roughly cylindrical attachment to the bird's upper bill. The casque is distinctive by virtue of its size, up to approximately 8 x 5 x 2.5 cm, and its peripheral color, which is a bright red. Other names for Hornbill casque "ivory" are "ho-ting" and "golden jade".

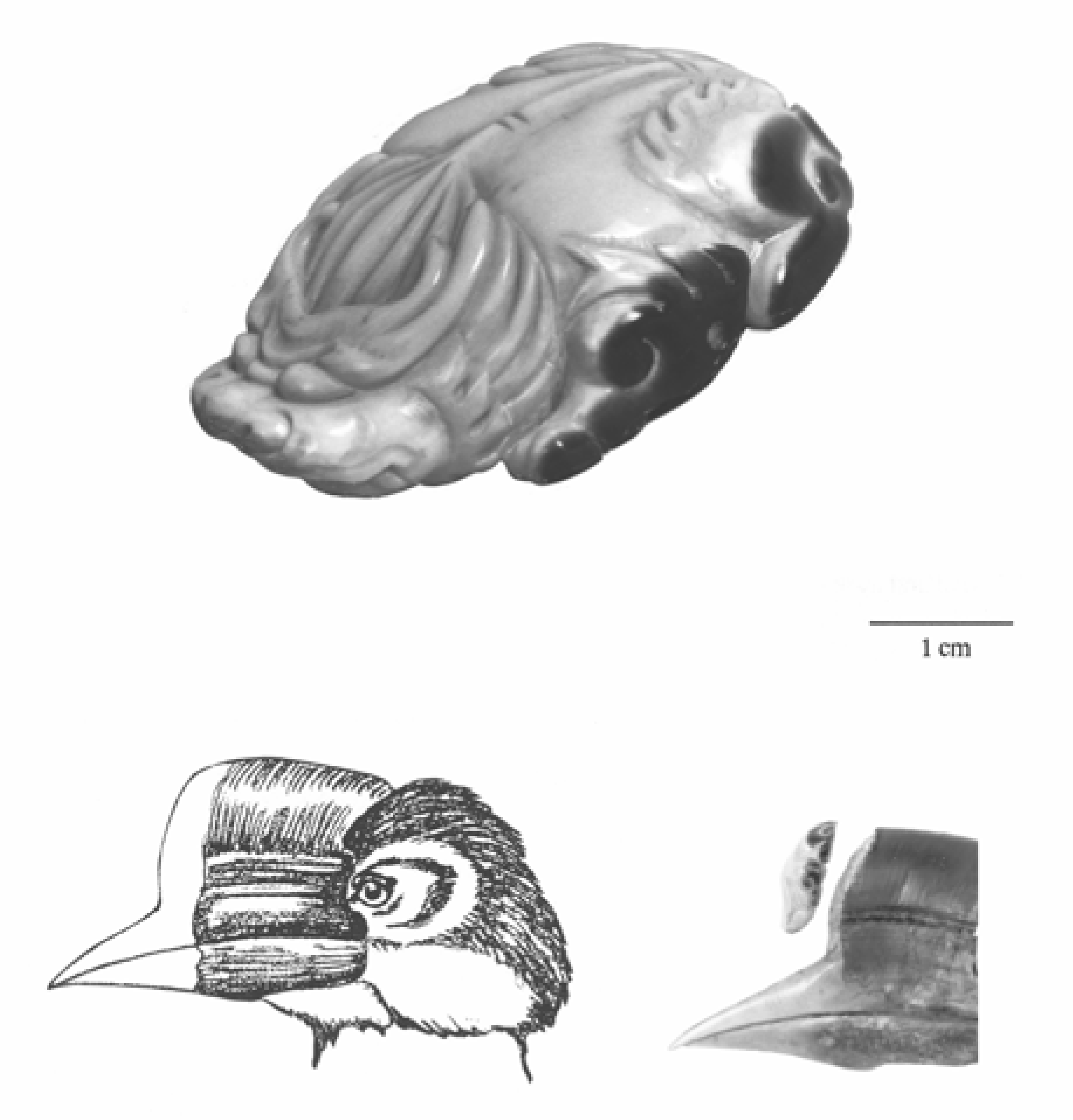



Figure 21. Photograph of a carved helmeted hornbill casque. Inserts are (left) a drawing of an intact hornbill head and (right) a photograph of a carved casque relative to its normal anatomical position. Note the peripheral coloration.

**Vegetable Ivory** *(Phytelephas macrocarpa)*

Vegetable ivory or ivory nuts are primarily the nuts of the Tagua palm tree *(Phytelephas macrocarpa)* although other palms of the same subfamily also produce ivory nuts. Tagua trees grow mainly in moist locations in northern South America. The mature nut, which can reach the size of an apple, has a very white, exceedingly hard cellulose kernel, which is worked like ivory. The husk of the nut (Fig. 22) has a dark brown appearance and is frequently incorporated into the carving.

Examination of the cellulose in carved vegetable ivory reveals a series of fine, regularly spaced concentric lines (Fig. 23) similar to those seen in the hippopotamus. Close examination with a low powered microscope reveals a grainy or lined appearance. These features may not always be obvious on highly curved surfaces. Vegetable ivory UV fluorescence is very similar to ivory fluorescence. In the absence of obvious morphologically identifying features, identification of vegetable ivory is best done using FT-IR. Perhaps one of the oldest field tests for differentiating vegetable ivory from real ivory is the addition of sulfuric acid to the item to be examined. Sulfuric acid applied to vegetable ivory causes an irreversible pink coloring in about 12 minutes. Genuine ivory should not stain. *CAUTION: Due to the irreversible nature of this test, only a minute dot of acid should be applied to the object in question.*

Figure 22 (left) Enlarged photograph of partially worked tagua nut showing cellulose kernel and husk.

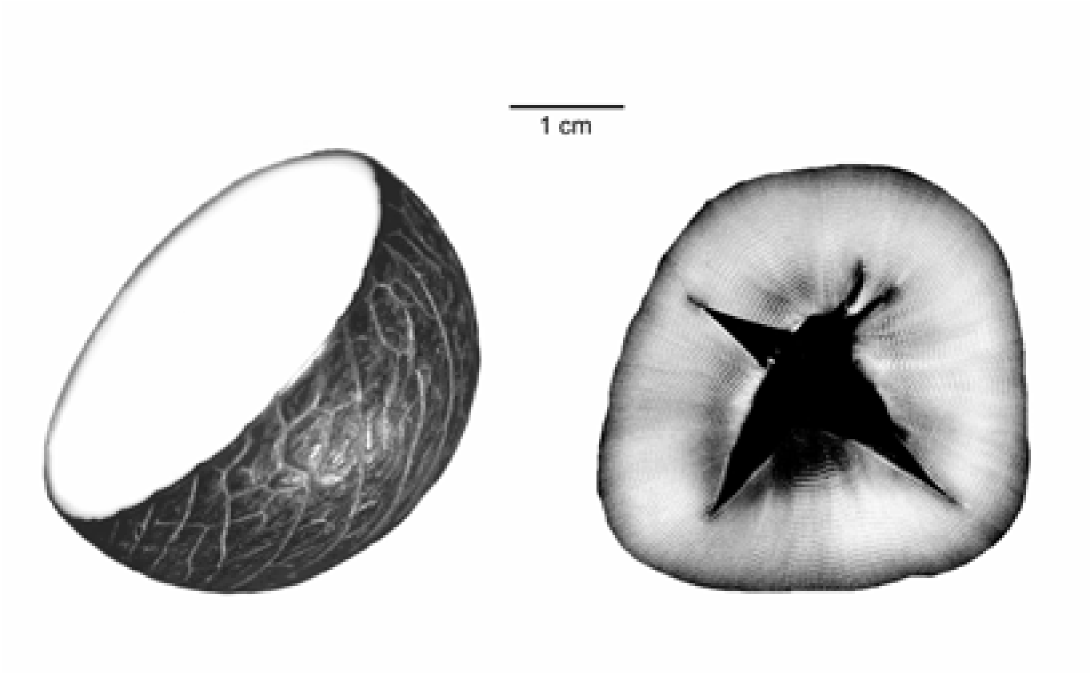



Figure 23. (right) Enlarged and enhanced photograph of a cross section of tagua nut. Note the presence of fine lines.

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## MANUFACTURED IVORY SUBSTITUTES

Manufactured ivory substitutes fall into three categories: 1) composites of an organic resin and an inorganic material; 2) composites of casein[2] and a resin material and, 3) composites of ivory sawdust[3] with a binder or resin. Trade names for some manufactured ivory substitutes are listed below.

### TABLE 4. EXAMPLES OF MANUFACTURED IVORY SUBSTITUTES

| TRADE NAME | COMPOSITION | MANUFACTURER AND/OR DISTRIBUTOR |
|---|---|---|
| Vigopas P71A | polyester resin | Raschig Corp.,<br>Richmond, Virginia, USA |
| Dekorit 203<br>Dekorit V384 | phenolic resin | Raschig Corp.,<br>Richmond, Virginia, USA |
| Galolith | casein + polyester | Fedra Design Ltd.,<br>Providence, Rhode Island, USA |
| Celluloid | cellulose nitrate + camphor<br>may contain casein | no longer manufactured |
| Composite polymer | ivory dust + styrene resin | |
| Ivorite | casein + hardener | Yamaha Corporation, Japan |
| Alabrite | calcium carbonate + adhesive binder | no longer manufactured |

Figures 24 and 25 are examples of manufactured ivory substitutes. Figure 24 is an early twentieth century celluloid, and Figure 25 is a modern polyester resin. Note the attempt to mimic a proboscidean pattern.

2 *Pure casein displays a UV fluorescence similar to ivory. The chemical structures, however, are easily distinguishable by FT-IR.*

3 *Ivory sawdust compositions are not ivory substitutes in the true sense of the term. They are subject to the same international trade controls and permit requirements as solid ivory products.*

Regardless of the appearance or chemical composition of the manufactured ivory substitutes, they all share a common identifying characteristics. When ultraviolet light is shined on manufactured ivory products they absorb the ultraviolet light exhibiting a dull blue appearance. Ivory, on the other hand, has a white/blue florescent appearance.

Identification of manufactured ivory substitutes is facilitated if standards of the manufactured ivories are available for comparative purposes when using the ultraviolet light

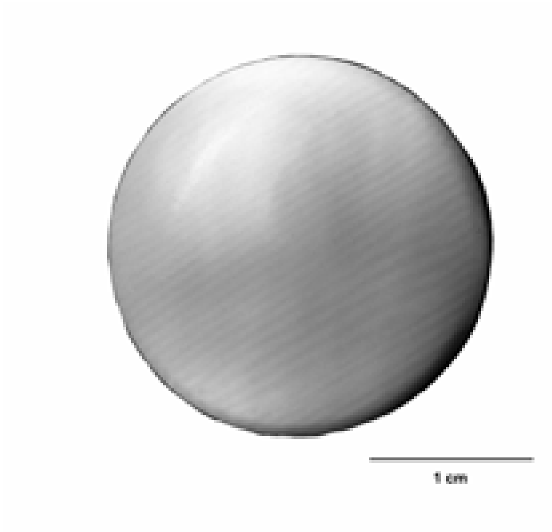


Figure 24. Enlarged and enhanced photograph of an early twentieth century celluloid ivory substitute. Note the design which attempts to mimic the pattern of proboscidean ivory.

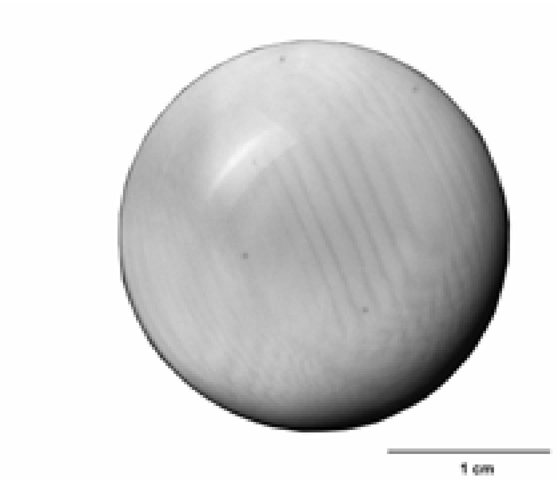


Figure 25. Enlarged and enhanced photograph of a modern polyester resin ivory substitute. Note the design which attempts to mimic the pattern of proboscidean ivory.

**ANNEX 1**

PROCEDURE FOR THE PRELIMINARY IDENTIFICATION OF IVORY AND IVORY SUBSTITUTES

The following is a suggested procedure for use in the preliminary identification of ivory and ivory substitutes. This procedure should be used in conjunction with the text descriptions and Tables 1, 2, and 3.

1. Examine object with long wave ultraviolet light*

2. Examine object for the presence of significant diagnostic morphological features (see Tables 1, 2, and 3).

3. If Schreger angles are present, see pages 10 – 13.

4. If no specific identification is suggested by steps 1 through 3, submit object for laboratory controlled instrumental analyses.

* *Long wave ultraviolet radiation is hazardous to the eyes. NEVER look directly at UV light.*

**ANNEX 2**

LIST OF SUPPLIES AND EQUIPMENT FOR USE IN THE PRELIMINARY IDENTIFICATION OF IVORY AND IVORY SUBSTITUTES

**Long wave ultraviolet light***

(Optional) Set of comparison standards consisting of exemplar pieces of ivory, bone, shell, vegetable ivory, and manufactured ivory substitutes

10X magnification hand lens

Photocopy machine with variable contrast

Ruler

Protractor

* *Long wave ultraviolet radiation is hazardous to the eyes. NEVER look directly at a UV light.*

## GLOSSARY

**Ameloblast:** enamel forming cell

**Artiodactyla:** the mammalian order which includes hippos and wart hogs

**Casque:** an enlargement on the upper surface of the bill of a hornbill bird

**Cementum:** a mineralized dental tissue which covers the dentine and causes the tooth or tusk to adhere to the jaw

**Cetacea:** the mammalian order which includes dolphins and great whales

**Class Characteristics:** features which identify an object as being a member of a group of similar objects

**Concentric:** having a common center

**Cross-section:** cut at a right angle to the long axis

**Dahllite:** a calcium phosphate mineral which comprises the majority of the tooth mass

**Dentine:** a mineralized dental tissue which serves as a temporary or permanent outer covering of a tooth or tusk

**Enamel:** a mineralized dental tissue which serves as a temporary or permanent outer covering of a tooth or tusk

**Extant:** in existence, not destroyed or lost

**Extinct:** no longer in existence, died out

**FT-IR (Fourier Transform Infrared Spectroscopy):** a non-destructive technique for the chemical analysis of materials based upon molecular interaction with infrared radiation. The analytical product of this technique is expressed in an inter ferogram

**Fossilization:** the process of replacement of naturally occurring components of a tusk or tooth with the elemental components of its environment

**Haversian System:** a series of interconnecting fluid transport spaces within a bone

**Hypercementosis:** a condition which results in unusually large depositions of cementum on a tooth

**Interstitial Zone:** an intervening space between convergent areas of dentine

**Macroscopic:** large enough to be observed with the unaided eye

**Mandible:** the lower jawbone

**Maxilla:** the upper jawbone

**Mean:** statistical average

**Microscopic:** small enough to require the use of a magnifying lens or microscope, not visible to the unaided eye

**Odontoblast:** dentine forming cell

**Pinnipedia:** the mammalian order which includes walruses

**Prismatic:** composed of prisms (crystal with specific face and edge configurations)

**Proboscidea:** the mammalian order which includes elephants and mammoths

**Schreger Pattern:** a system crossing lines which is unique to proboscidean ivory

**Scrimshaw:** engraved or shallowly carved bone or ivory

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