ELEPHANTS · ANATOMY, FORENSICS & LAW

Ivory

What a tusk is made of, how it grows, how ivory is identified and traced — and what the law in Zimbabwe requires.

SERIES **SAFARI NOTES** FORMAT **FIELD & GUIDING NOTES** PUBLISHED BY **THE SAFARI SHOW**

> An elephant's tusk is a tooth — an upper incisor that never stops growing. Its layers record the elephant's diet and where it lived, its cross-section can tell elephant from mammoth, and in Zimbabwe raw ivory must be registered and marked with a distinctive stamp.

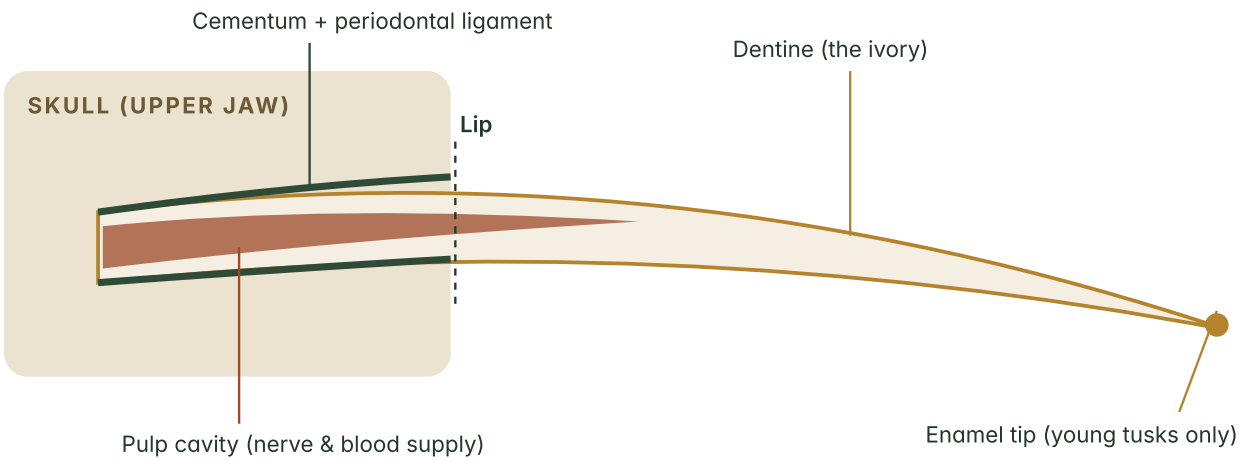
01 A tusk is a tooth

A typical mammal tooth has a **crown**, a **neck** and a **root**, and is built from three hard tissues. An elephant tusk is a modified upper incisor, and the same three tissues are present — but in very different amounts.

TISSUE	WHERE IT IS IN A TUSK	WHAT IT DOES
Dentine	Almost the whole tusk	The "ivory" itself. Laid down by cells called odontoblasts around a central pulp.
Cementum	A thin layer over the part inside the skull	Together with the periodontal ligament, anchors the tusk in its socket in the upper jaw.
Enamel	Only on the tip of a young elephant's tusk	Wears away quickly and is never replaced, so adult tusks have none.

Like all teeth, a tusk forms from a tooth bud in which the enamel-forming and dentine-forming tissues develop side by side and signal to each other. That is why even a tusk — which is nearly all dentine — starts life with a small cap of enamel.

02 Inside a tusk



Simplified tusk (not to scale). The pulp cavity runs from the base inside the skull towards the lip; in adult bulls it can extend some way beyond the lip.

03 Milk tusks: the “tush”

An elephant’s permanent tusk is preceded by a small **deciduous (milk) tusk, the tush**. Research on African elephants shows the tush and the tusk develop from the **same tooth germ**, in the same milk-tooth-to-adult-tooth relationship as our own teeth.

- Tushes reach a maximum length of only about **5 cm**.
- A 1995 anatomical study of foetuses and calves under a year old found the tushes did not appear to break through the skin; they were **pushed aside and resorbed** as the permanent tusk grew. It concluded the tush **has no obvious function** other than setting the position and direction for the permanent tusk.
- Elephant-care sources describe tushes being lost at **around one year**, and the permanent tusks beginning to show beyond the lip at **about 2–3 years**.

Guides sometimes say tushes exist to protect the mother’s teats from a calf’s sharp tusk. That is a reasonable idea, but we found no study that tests it.

04 How tusks grow: bulls vs cows

A long-term study of tusks from Kruger National Park found that bulls and cows grow ivory very differently:

BULLS

Faster, and faster again

Tusk mass increases at an **accelerating rate throughout life**, and the pulp cavity keeps growing. A bull puts on much of his ivory in his later decades — so a modest tusker in his thirties may carry far heavier tusks by his late forties.

COWS

Steady, then levels off

Tusk mass increases steadily until about **40–45 years**, then levels off or falls, probably through breakage and wear. The pulp cavity starts to close at about 40.

05 Which animals have ivory?

Strictly, “ivory” means elephant tusk, but the term is accepted for other mammal teeth and tusks traded commercially. The CITES ivory identification guide covers:

ANIMAL	SOURCE OF THE IVORY
Elephants & mammoths	Upper incisors (tusks)
Walrus	Upper canines (tusks) and teeth
Narwhal	A single upper incisor (usually the left)
Sperm whale & killer whale	Teeth
Hippopotamus	Upper and lower canines, and lower incisors
Warthog	Upper and lower canines (tusks)

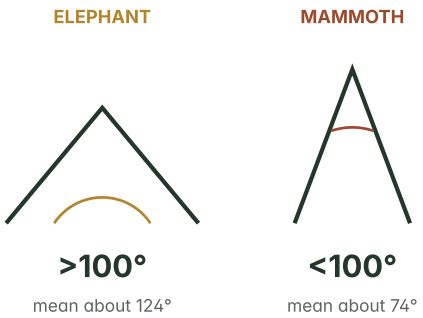
06 Schreger lines: elephant or mammoth?

Cut an elephant tusk across and you see a criss-cross pattern of lines in the dentine — **Schreger lines**, also called cross-hatching, engine-turning or stacked chevrons. This pattern is found only in proboscidean ivory (elephant and mammoth), which makes it the classic first test in ivory forensics.

The **outer** lines near the cementum are easy to see; the **inner** lines around the pulp are faint. Where the lines cross they form angles, and the angles in the outer zone are the key measurement:



Schreger lines in polished elephant ivory.



Outer Schreger angles (simplified)

THE NUMBERS

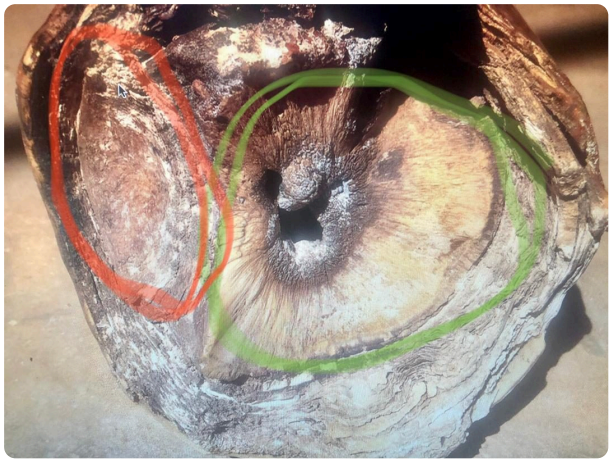
In the CITES/US Fish & Wildlife guide, every modern elephant sample averaged outer angles **above 100°**, and every mammoth sample **below 100°**; across all samples, the same authors report means of about 124° for elephant and about 74° for mammoth. But angles between about **90° and 115°** occur in both, so in that range the angle alone should never be used to decide.

07 Broken tusks and pain

Tusks break — in fights, while digging, or through disease. Whether a break hurts depends on how deep it goes.

- The **pulp** contains the nerve and blood supply. A South African veterinary study states plainly that fractures or amputations that **expose the pulp cause pain**.

- The same study found that pulp length is linked to the tusk's circumference at the lip, and that cutting a tusk **more than 300 mm beyond the lip** should not expose pulp, whatever the elephant's age or sex.
- When the pulp is damaged, the tusk responds by laying down **reparative (tertiary) dentine**.
- A study of tusk fractures in zoo elephants notes that pain is especially likely when damage extends to the **periodontal ligament** that holds the tusk in its socket, or to the base of the pulp; infection around the tusk can also occur.



A fractured tusk in cross-section. The zone circled in green, around the pulp canal, is interpreted as reparative dentine laid down after the injury.

Some guiding literature argues that pain from a broken tusk is less severe than a broken human tooth, because the tusk's root stays open and pressure can't build up. We could not find a published study supporting this; the veterinary literature treats pulp exposure as painful.

08 What ivory can tell us

DIET

A lifetime menu

Dentine is laid down in layers, so it records diet over time. Trees and shrubs (C_3 plants) and grasses (C_4 plants) leave different carbon-isotope signatures. Serial sampling of Kruger tusks produced decades-long diet records, showing each elephant switched between browsing and grazing across seasons and years — and that grass intake rose through the 20th century.

ORIGIN

Tracing seized ivory

Isotopes help too: strontium reflects the local geology, while carbon and nitrogen reflect diet and rainfall, together pointing to the area an elephant lived in. DNA extracted from ivory can be matched to a genetic reference map built from elephant dung and tissue across Africa — used to trace large seizures to poaching hotspots, and to tell forest from savanna elephant ivory.

09 Record tusks

RECORD	DETAILS	STATUS
Heaviest pair	The "Kilimanjaro tusks": a bull shot on the slopes of Kilimanjaro, usually dated to 1898, reportedly by Senoussi, an ivory hunter working for the trader Tippu Tip. Each tusk weighed roughly 100 kg; published figures vary from about 214 to 235 lb per tusk. Reported to be held by the Natural History Museum, London.	WIDELY REPORTED — FIGURES VARY

RECORD	DETAILS	STATUS
Longest tusk	3.49 m along the outside curve (its partner 3.35 m), from an elephant from the Democratic Republic of Congo; held by the New York Zoological Society (Guinness World Records).	GUINNESS RECORD
Heaviest in Kruger	**Mandleve**, who died of old age in 1993 at about 56: tusks of 73.5 kg and 69 kg. Displayed at Letaba Elephant Hall.	SANPARKS
Zimbabwe	A 140 lb tusk from a bull on the lower Rukomechi River (about 1983), and a 132 lb tusk taken in Gonarezhou when parts were hunting areas (2.87 m long, 20″ circumference).	GUIDING RECORDS — UNVERIFIED

Kenya, Tanzania and Kruger have traditionally been known for heavy-tusked bulls. Today Tsavo is described as holding the last notable population of big tuskers in Africa.

10 Ivory and the law in Zimbabwe

Zimbabwe's elephants have been listed on **CITES Appendix II since 1997** (with Botswana and Namibia; South Africa followed in 2000). Before that, from 1989, all African elephants were on Appendix I. Under CITES, sport-hunted ivory may cross borders only as a non-commercial hunting trophy.

Ivory ownership is controlled under the Parks and Wild Life (General) Regulations, 1990, which require raw ivory to be registered and marked, with a **certificate of ownership**:

1. **Register within 15 days** of acquiring ivory (24 hours if imported). Guide training teaches that for a hunt this runs from the end of the hunt.
2. Take the ivory and proof of lawful acquisition (e.g. the permit) to Parks. Each tusk is **weighed, measured and stamped**, typically with country code, year, serial number and weight, recorded in kg (e.g. *ZW 2019 23125 24*).
3. The details are entered on an **ivory ownership registration card** (certificate of ownership). For export, a CITES tag and export permit are then applied for. Ivory that is not exported must still be registered the same way.
4. **Lost or stolen ivory:** return the certificate of ownership to the Director-General within 14 days, with details of the theft report.
5. **Passing ivory to someone else** (for example as a gift): the certificate of ownership must immediately be endorsed with the new owner's name and address, signed and dated.



Registration stamp on a tusk.



CITES elephant trophy export tag.

CHECK BEFORE YOU RELY ON IT

The time limits are in the 1990 regulations (ss. 77 and 81); the hunt timing comes from guide training. Regulations can be amended, so check current requirements with ZimParks.

11 Judging tusk weight in the field

Professional hunters use a rough **rule of thumb**: multiply the tusk's **circumference at the lip (inches)** by the **length of ivory showing (feet)** for a basic weight figure in pounds. Take off about 10% if the lip circumference is under 18″, and add about 10% if it is over, because thick ivory is denser. To judge circumference, know your own hand spans — middle finger to middle finger and thumb to thumb with both hands around a tusk is usually about 16–17″ — and the tip of an elephant's trunk is about 13″ round.

This is a field estimate passed between hunters and guides, not a tested formula. Remember too that a large share of each tusk is hidden inside the skull, and that part is hollow where the pulp runs from the base to the lip.

12 After death

The tusk is held in its socket by the periodontal ligament. After an elephant dies, the tusks can be pulled out once this ligament rots — field experience suggests roughly one to two weeks, depending on weather and bacteria. Hunters have suggested it may be faster when an elephant has been poisoned, but we found no study on this.

AT THE SIGHTING — HOW TO SAY IT

"Those tusks are teeth — upper incisors that keep growing his whole life. Almost all of it is dentine, the same stuff as under your enamel. Bulls like him put on ivory faster and faster as they get older, which is why the really big tuskers are old bulls. And every layer of that ivory is a record of what he ate — scientists can read decades of an elephant's diet from a single tusk."

Quick revision: Q&A

What are the three parts of a tooth, and its three hard tissues?
Crown, neck and root; enamel, dentine and cementum.

What is ivory mostly made of?
Dentine. Cementum covers the part in the skull; enamel is found only on the tip of young tusks.

Do elephants have milk tusks?
Yes — tushes, up to about 5 cm, from the same tooth germ as the permanent tusk.

When do permanent tusks show?
At about 2–3 years old.

Which animals produce ivory?
Elephants and mammoths, walrus, narwhal, sperm and killer whales, hippo and warthog.

How do you tell elephant from mammoth ivory?
Outer Schreger angles: elephant above 100° (mean ~124°), mammoth below 100° (mean ~74°); 90–115° is a grey zone.

Does a broken tusk hurt?
If the pulp is exposed, yes; injuries to the socket and ligament are also painful.

What can ivory reveal?
Diet over time (carbon isotopes) and origin (strontium and other isotopes, DNA).

Zimbabwe's elephants are on which CITES Appendix?
Appendix II, since 1997.

Can sport-hunted ivory be sold abroad?
No — CITES allows it to be exported only as a hunting trophy for non-commercial purposes.

SOURCES

- Espinoza, E. O. & Mann, M.-J. (1991; CITES reprint 1999). *Identification Guide for Ivory and Ivory Substitutes.* WWF / The Conservation Foundation / CITES Secretariat. https://cites.org/sites/default/files/fra/resources/pub/F-Ivory-guide.pdf
- Espinoza, E. O. & Mann, M.-J. (1993). The history and significance of the Schreger pattern in proboscidean ivory characterization. *Journal of the American Institute for Conservation* 32(3): 241–248.
- Raubenheimer, E. J. (2000). Development of the tush and tusk and tusklessness in African elephant (*Loxodonta africana*). *Koedoe* 43(2): 57–64. https://koedoe.co.za/index.php/koedoe/article/view/199
- Raubenheimer, E. J. et al. (1995). Morphology of the deciduous tusk (tush) of the African elephant. *Archives of Oral Biology* 40(6): 571–576. https://pubmed.ncbi.nlm.nih.gov/7677604/
- Knysna Elephant Park. The teeth & tusks. https://knysnaelephantpark.co.za/teeth-tusks/
- Whyte, I. J. & Hall-Martin, A. (2017–18). Growth characteristics of tusks of elephants in Kruger National Park. *Pachyderm* 59. https://pachydermjournal.org/index.php/pachyderm/article/download/78/39/181
- Steenkamp, G. et al. (2008). Estimating exposed pulp lengths of tusks in the African elephant. *Journal of the South African Veterinary Association* 79(1): 25–30. doi:10.4102/jsava.v79i1.236
- Rose, J. B. et al. (2022). Treatment and outcomes of tusk fractures in managed African savanna and Asian elephants across five continents. *Animals* 12(9): 1125. doi:10.3390/ani12091125
- Codron, J. et al. (2012). Stable isotope series from elephant ivory reveal lifetime histories of a true dietary generalist. *Proceedings of the Royal Society B* 279: 2433–2441. doi:10.1098/rspb.2011.2472
- van der Merwe, N. J. et al. (1990). Source-area determination of elephant ivory by isotopic analysis. *Nature* 346: 744–746. doi:10.1038/346744a0
- University of Washington. Putting a stop to poaching (Wasser lab ivory DNA). https://www.washington.edu/boundless/putting-a-stop-to-poaching/
- Pondoro. Great tuskers on safari (Kilimanjaro tusks). https://pondoro.co.za/blog/great-tuskers-on-safari/ ; Africa Geographic. Africa's big tuskers. https://africageographic.com/stories/africas-big-tuskers/ ; Sports Afield. A really big tusker (2019). https://sportsafield.com/2019/a-really-big-tusker/
- Guinness World Records. Longest tusk. https://www.guinnessworldrecords.com/world-records/70455-longest-tusk/
- SANParks. Past tuskers (Mandleve). https://www.sanparks.org/parks/kruger/elephants/tuskers/past.php
- CITES CoP19 Prop. 4 (2022) — history of elephant Appendix listings. https://cites.org/sites/default/files/documents/E-CoP19-Prop-04_1.pdf
- CITES Resolution Conf. 10.10 (Rev. CoP18), paragraph 2: marking of whole tusks.
- Parks and Wild Life (General) Regulations, 1990 (SI 362 of 1990), Zimbabwe, ss. 77–81. https://huemul.cms.int/sites/default/files/document/cms_nlp_zwe_statutory_instrument_362_1990.pdf

— SAFARI NOTES · THE SAFARI SHOW —