

Session 6: Episode 1 - Early technologies for making living memory explicit

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Tonight

- Tonight we start looking at cognitive technologies in detail
- Episode 1 concerns knowledge and its interactions with technology

EPISODE 1 - Counting, Writing, Books, and Printing

Numeracy, Counting Boards, Chinese Counting Sticks, and the Abacus
Writing

Writing and the keeping of records

Writing and the development of scholarship

Replicating, Preserving, and Disseminating Knowledge

Replicating Written Knowledge with Printing

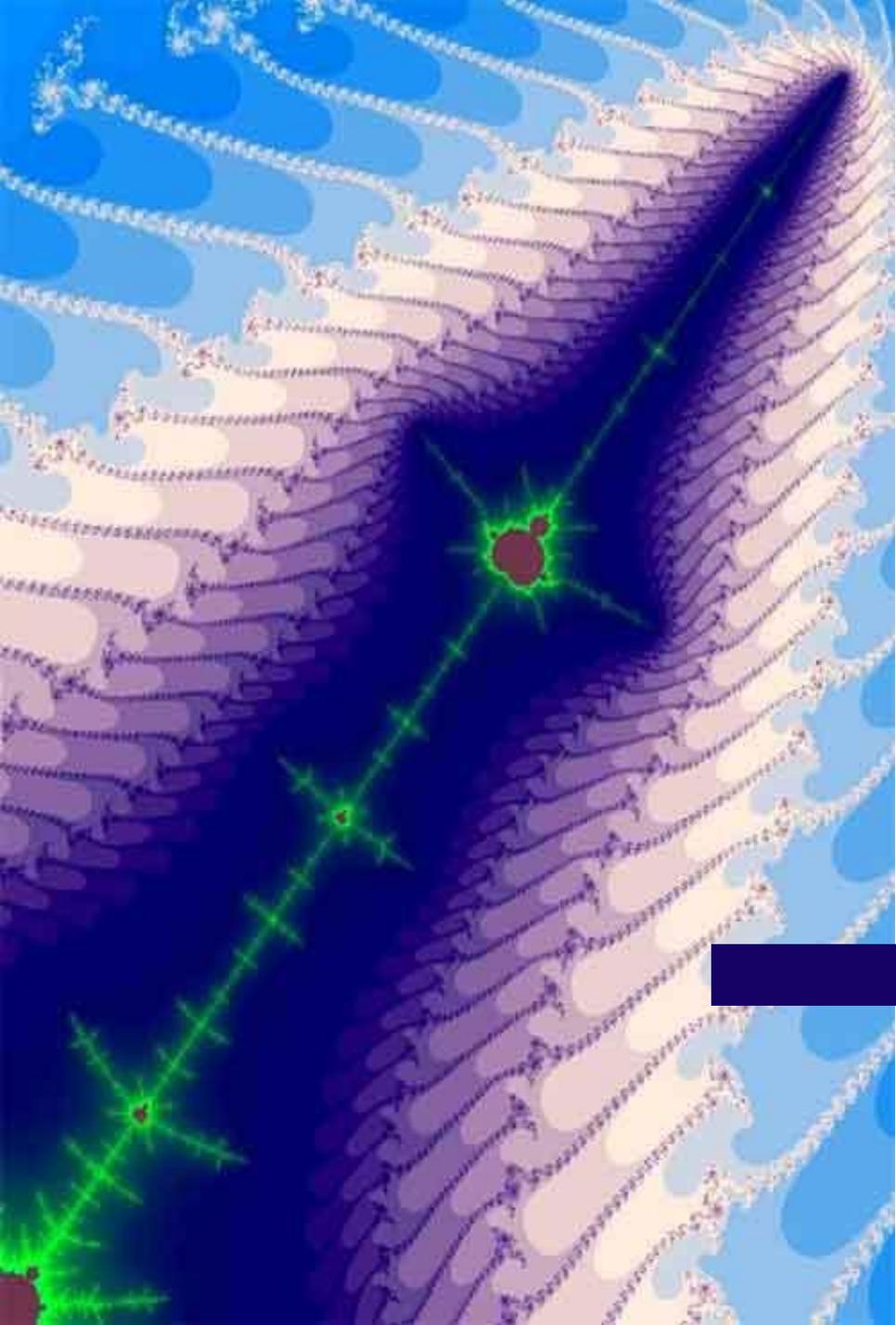
Setting words into print -printing and typesetting

The Second and Third Printing Revolutions - industrializing and automating the production of words on paper

Prelude: Accumulating Written and Printed Knowledge

Books, Journals and Libraries

Library structure and catalogs helped individuals find books

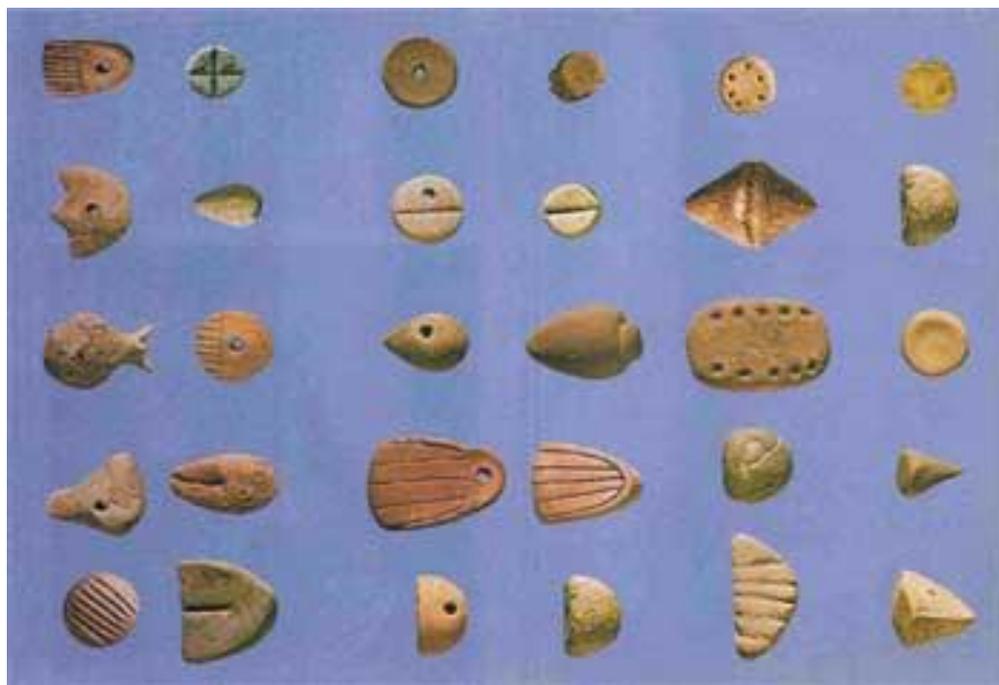


**Counting probably
preceded writing
because of the
importance of
quantification in
economic exchanges**



Speech & memory are fallible means for recording the quantitative details of a trade

- Fair exchange depends on an agreement that is acceptable to both sides and survives the test of time
 - Needs an inter-subjectively tangible and persistent record of the agreement
 - Presumably quantification was achieved by counting fingers and piling stones as tokens to represent the numbers involved in the trade
- Trading in a big way would have developed along with the Agricultural Revolution and rise of the city state
 - First evidence for counting tokens from ~ 10,000 years ago
 - In time different tokens were used to signify different commodities
 - Note that many tokens perforated - allowing them to be threaded onto a string
- **Counting also involved cognitive changes to think of a number line**



Counting provided a threshold for the revolutionary invention of writing

- Tokens quantifying a particular transaction also came to be kept in clay pouches (bullas) that would be broken open to confirm consummation of a transaction
 - Easier to keep a visible record by pressing token shapes onto the outer surface of the freshly formed bulla
 - Shape could also be inscribed onto the clay for the gradual emergence of idiographic writing
- Easy transition to developing idiographic writing for keeping transaction records
- True writing (at least in Ur) may have been invented by a single individual around 5,500 years ago

Evolution from Token to Cuneiform Writing

Token	Pictograph	Neo-Sumerian/ Old Babylonian	Neo-Assyrian	Neo-Babylonian	English
					Sheep
					Cattle
					Dog
					Metal
					Oil
					Garment
					Bracelet
					Perfume

Evolution of some ancient clay tokens in relation to cuneiform writing and their possible English meaning.

What is writing?

- Writing is a system to “represent an utterance in such a way that it can be recovered more or less exactly without the intervention of the utterer”
 - Major revolution that enabled the rise of bureaucratic nation state.
 - Picture from the Darius Vase showing a scribe calculating (on a counting board ancestral to the abacus) and recording in a wax tablet the collection of tribute



Writing and the development of scholarship

- Limitations of ancient writing
 - Labor intensive to create the written document
 - Limited by available substrates
 - Ponderous clay tablets
 - Fragile/ephemeral wax sheets, slices of wood
 - Expensive to produce and indurable papyrus
 - Extremely expensive vellum (specially prepared animal-skin)
- The continuous scroll vs the revolutionary codex
- The “book” as a memory aid for a coherent body of knowledge
 - Illumination makes each page/passage memorable
 - Cost of production made each codex a priceless artifact
 - In most cases there was only ever one copy of the book
 - If it wasn't copied the knowledge it contained was lost
 - Copying also introduced errors
- “Libraries” as tools for accumulating and sharing knowledge

The Printing Revolution and the Reformation: Printing changed the economics of knowledge

- 100s to 1000s of *exact* copies could be printed for the price of one scribal copy
 - Scholars no longer forced to travel to priceless copies of unique books chained to shelves of scattered monasteries.
 - Possible to build private libraries
 - Cross-check ideas among several authorities

MARCI VELSERI,
MATTHÆI F. ANTI. N.
REIP. AUGUSTANÆ
QUONDAM DUUMVIRI.
OPERA
HISTORICA
ET PHILOLOGICA,
SACRA ET PROFANA.

In quibus
Historia Boica, Res Augustanae, Conversio &
Passio SS. Martyrum, Afriz, Hilarie, Dignæ, Eunomia,
Europæ, Vitæ S. Udalrici, & S. Severini, Narratio vocum, quæ coelegant
Apollonio Tyrio, Tabula Pevtingerana integræ, Epitola ad Viros
Illustres Latæni Italique, & Proceres supra continentur.

Accessit
P. Optatiani Porphyrii Panegyricus,

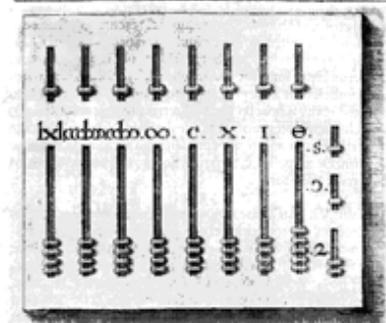
Conferentis M. anstus,
exoptimo Codice PAULLO VELSERO divulgatus,
multamque Criticam Cræthæi Desaut.

Præfatio in fine
Præfatio ad Lectorem, de singulis scriptis nunc recensis,
juxta Virorum eruditissimorum sententias:

De sen
VITA, GENUS, ET MORS
AUCTORIS NOBILISSIMI.
Amantiss
CHRISTOPHORO ARNOLDO.

NOLIMBERGÆ.
Typis ac sumptibus WOLFGANGI MAURITII, & Filiorum
JOHANNIS ANDRÆ, ENDERGORUM
ANNO MDLXXXII.

AD VIROS ILLUSTRES. 819



Abacus aeneus est, forma & magnitudine, quam chartula exprimit. Foramina scilicet, ordines five alveoli, in superiori parte octo, totidem in inferiori parte. In superioribus singulis alveolis singuli sunt clavicali umbellati, five capitibus laterioribus, ita ut hinc inde moveri queant, nec tamen excidant. In alveolis inferioribus singulis quaterni sunt familes clavicali ductiles & umbellati, præterquam in alveolo Θ, signato quinque clavicali sunt: rursus in tribus alveolis, qui extra reliquorum ordinem, in duobus quidem s. & notatis singuli sunt clavicali, in 2. verò duo sunt. Clavicali itaque in universum xlv. omnes mobiles Parte ad versa characteres incipere, quos dixi Θ, s. 2. 2. Dein numeri i. x. c. o. cclxxx. h. l. parte ad versa nullæ notæ, clavicali tamen, quod necesse est, hinc quoque in alveolis conspicui: ad angulos quatuor lunule paulo crassiores, & magis quam clavicali extantes, annexæ sunt, hæc abacum fulcrum, ne clavicalium usus impediatur.

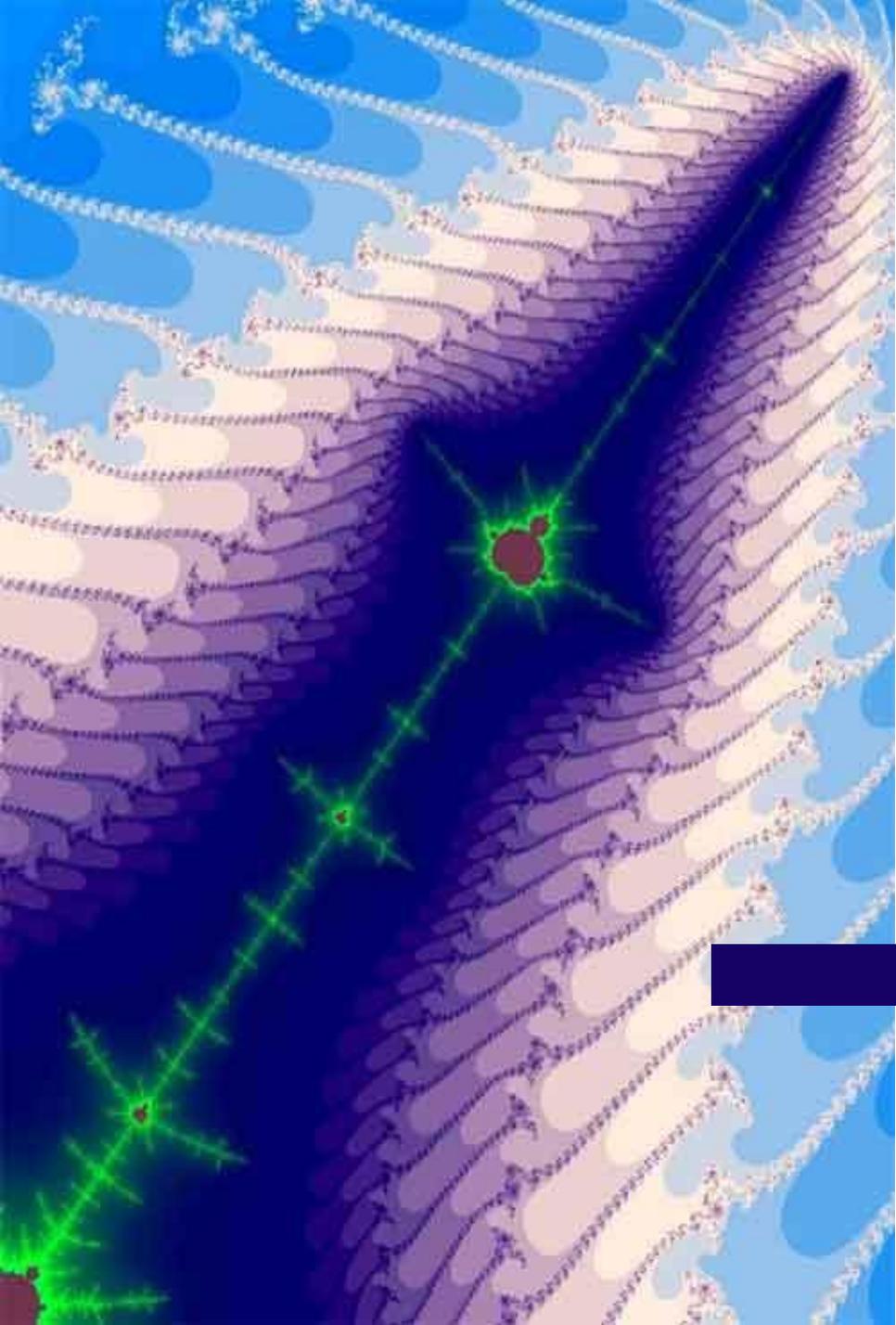
Ullus videtur fuisse hujusmodi, ut in xlv. alveolis, quibus numeri sub vel supra scripti clavicali inferiorum alveolorum singuli tot numeros, puta alies aut fellerios notarent, quot character interjectus: superiorum verò clavicali uno amplius quam inferiores clavicali ejus alveoli omnes. Quo posito facile est intelligere, quomodo ductione clavicalium, quibus l. interjecta est, exprimerentur inferioribus omnibus quatuor, superiori unico quinque, itaque collectim novem: fuerit addendus decimus, redaccebantur hi clavicali, & moveretur primus inferioris

LIII 2 alveoli

- Completed the Renaissance and fuelled the Reformation
 - Possible to standardize ancient texts and cross-check against W1
 - **When any thinker could own and read their own bible, why should some priest's interpretation of the words confer absolute authority?**

With printing books became more important as reference aids than aids memoire

- When individuals could build libraries of multiple books, the books needed to provide cognitive tools to identify and locate specific knowledge in them
 - title pages and prefaces,
 - publication details,
 - numbered pages,
 - indexing,
 - table of contents,
 - woodcuts & metal engravings for illustrations, detailed charts and diagrams,
 - folded plates (i.e., oversize pages for high quality illustrations),
 - cross referencing,
 - paragraphing and styles for parsing the content
- Books referencing other books
 - footnotes and bibliographies
- **Growth of literacy until it becomes nearly universal**



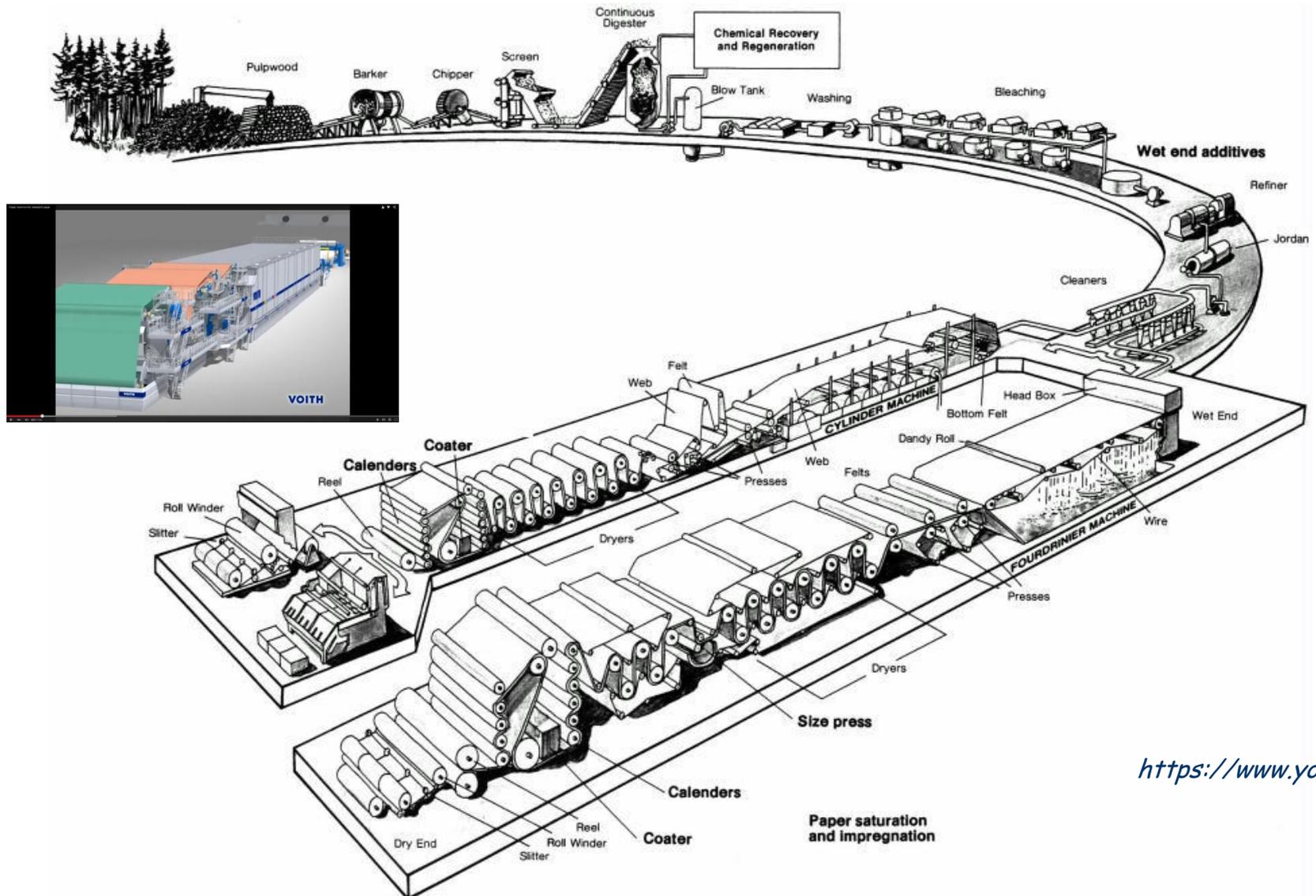
Technology for recording knowledge in writing and printing



Printing Revolution concatenated several revolutionary technologies

- Paper making (e.g. Handmade Paper Making Operation in Kathmandu, Nepal)
 - Not obvious that plant pulp could be processed to make good/standardized writing material for much less cost than papyrus
 - "Normal" tech development → Fourdrinier paper making
- Printing combines technologies in unexpected ways
 - Moveable type (derived from seals and stamps) & typesetting to lay out a page of text at a time
 - A press (derived from a wine/olive press)
 - Paper and inks
 - Book binding
 - "Normal" tech development → Linotype and continuous web press
- **Hundreds of books to millions** in a week

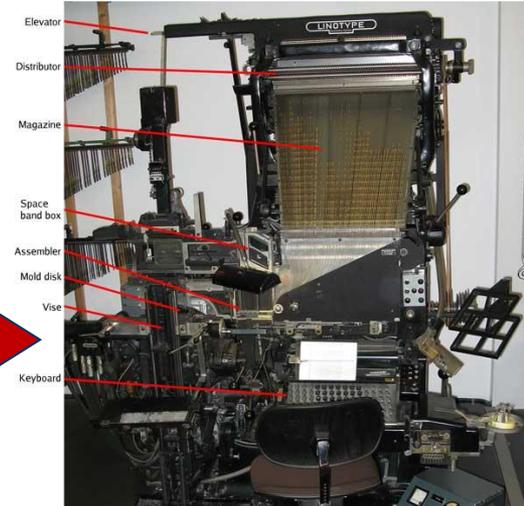
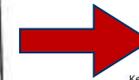
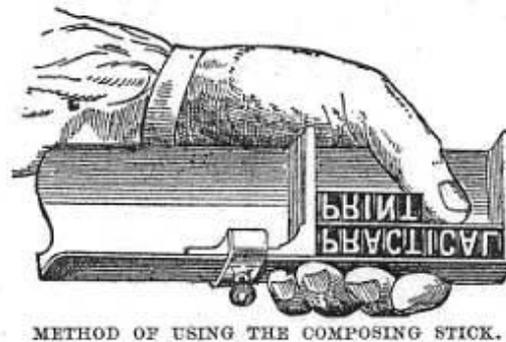
The Fourdrinier paper machine



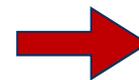
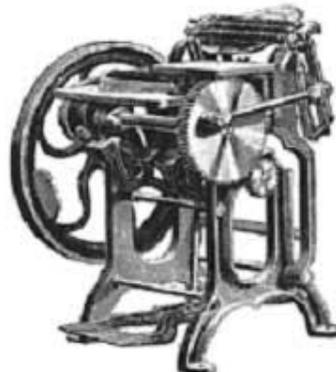
[https://www.youtube](https://www.youtube.com/watch?v=...)

From that to this in ~500 years

- Typesetting from hand to Linotype



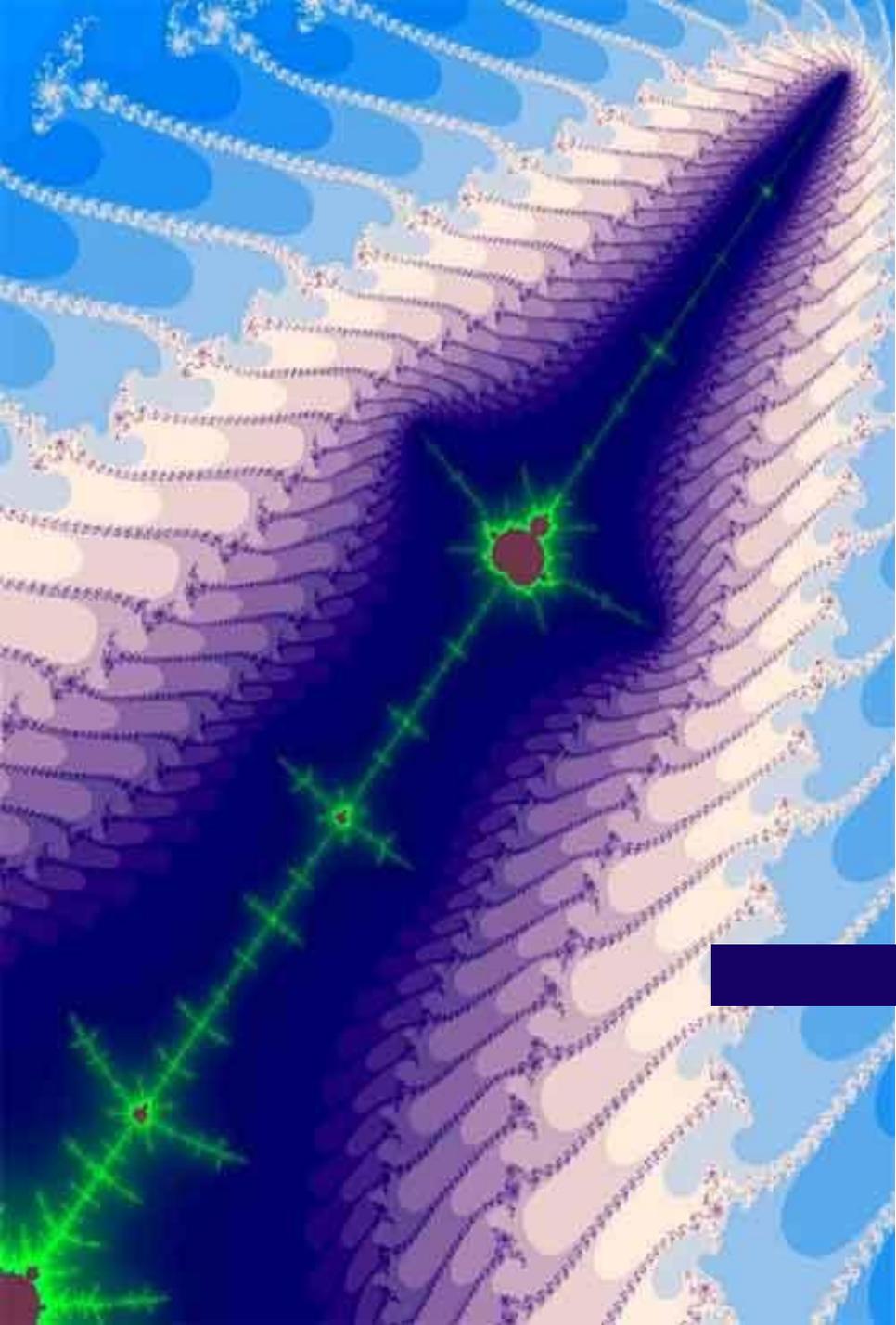
- Printing from hand press, and letter press, to rotary web press



Except for cardboard and Kraft paper all these printing technologies are already are or will be extinct by 2040

- Fairfax Press has scrapped its state of the art printing plants in the last year, including the Age's 10 year old plant at Tullamarine





**Accumulating, sharing,
and building on recorded
knowledge**



Ancient scholarship and teaching

- Ancient libraries
 - As soon as writing was required for recording administrative activities it made sense to organize records in central repositories so that records could be found at a later date
 - 2100 BC archives of cuneiform tablets in Nineveh
 - Ashurbanipal's library mid 7th Century BC Nineveh
- The "universal library" and university (Alexandria, c. 280 BC - the **Bibliotheca** and the **Mouseion**)
 - Attempted to collect a copy everything written
 - Resident scholars devoted to building knowledge & technology
 - As books need tables of contents and indexes, libraries need catalogs and subject indexes
 - The importance of schemes to classify and index knowledge eventually led to the development of **Information Science**
- **Because everything was hand-written there was only ever one copy of most things**
 - This fabulous collection of knowledge and wisdom was largely lost

Standardization, verification, and formalization of knowledge led to the Scientific and Industrial Revolutions

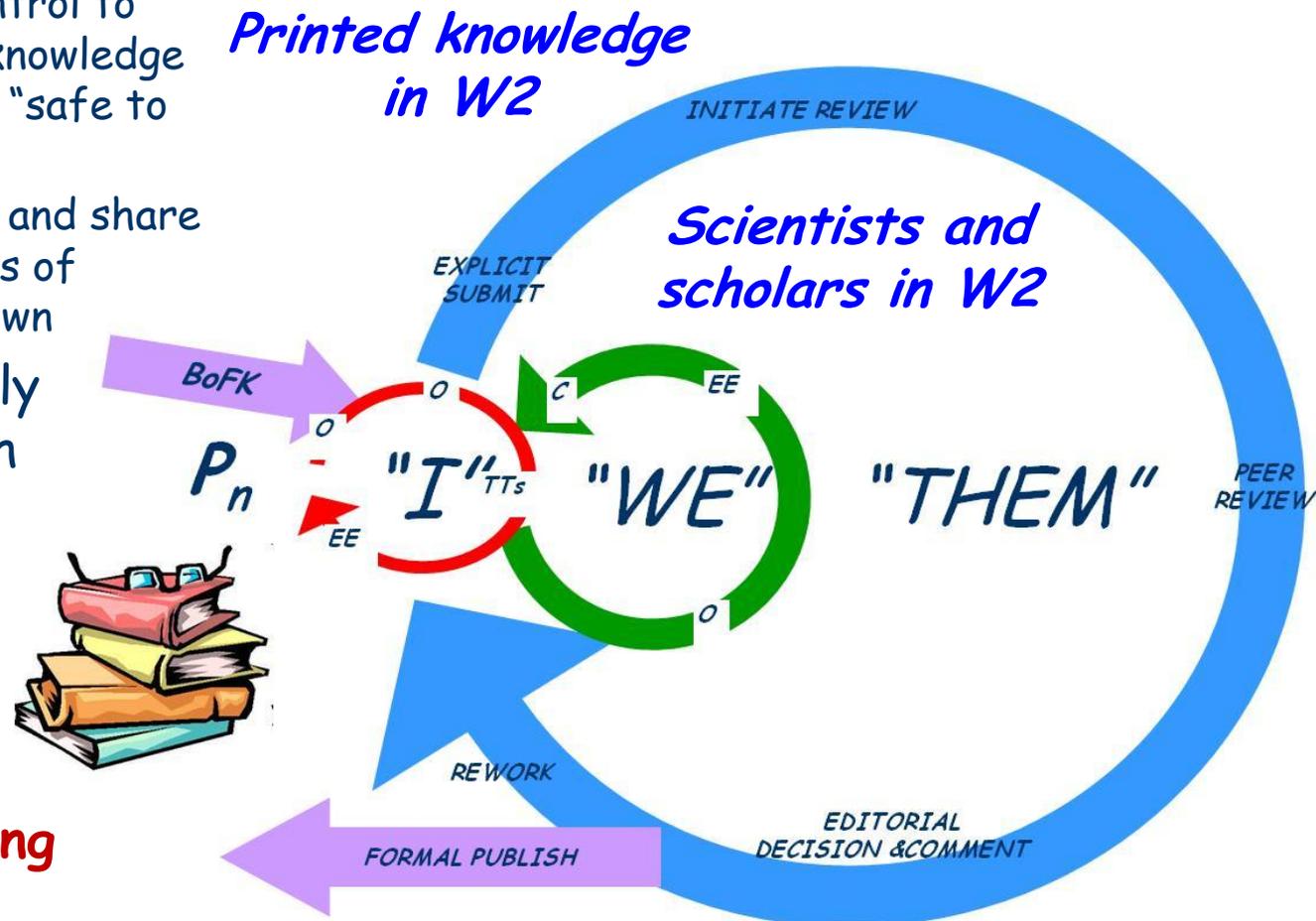
- Surviving scraps of ancient knowledge were translated into print and circulated
 - Multiple copying allowed different texts to be brought together and compared with one another and new knowledge gathered from the external world to build a standardized understanding of the world that could then be built upon
- The emergence of peer-review and the scientific journal
 - See
 - Hall, W.P., Nousala, S. 2010. What is the value of peer review - some sociotechnical considerations
 - Vines, R., Hall, W.P., McCarthy, G. 2011. Textual representations and knowledge support-systems in research intensive networks
 - Vines, R., Hall, W.P. 2011. Exploring the foundations of organizational knowledge
- Science and the accumulation of technical knowledge
 - Replacement of guild halls as a means for the secret transmission of technical knowledge by universities, books, and knowledge for the building and accumulation of public knowledge.

"Libraries" as tools for accumulating and sharing knowledge

- Knowledge grows by accumulating, intermeshing, and sharing knowledge
 - Quality control to formalize knowledge considered "safe to use."
 - Need form and share repositories of what is known

- Until recently the research library was the primary tool used in this process

- **Now becoming obsolete!**



Next Week

- I'll explore how mechanical computation and automation in the ancient Greek world contributed to the rise of mechanical computation in the first half of the 20th Century.

EPISODE 2 - Automating Cognition

Automation Technology and its Replication

Forgotten and Invisible Generations of Computing and Automation

Antikithera Mechanism - 2100 year old gear driven analog computer/simulator

Automated theaters, temples, and toys

18th Century androids and automatons

Forgotten knowledge is lost knowledge

Zeroth Generation: Mechanical Technologies for Calculation

Logarithmic technologies

Gear-driven digital calculators

Analog computation

Automating calculations with technology from the weaving industry