

CSCI 1377

Tools for Thought

Reading II

Reading Augmentation Systems

“A product’s efficacy and scientific support are no prerequisites to commercial release. But occasionally, when an idea has appeal for both fundamental and practical reasons, science may step in to bear the burden of proof.”

— Joshua Snell, “No, Bionic Reading does not work” (2024)

“The paperless office”

<https://youtu.be/pJoH6XuUsoY>

<https://youtu.be/M0zgJ2p7Ww4>

Researchers embedded at the IMF in 1995



By ajay_suresh, CC BY 2.0, via Wikimedia Commons

Workers used documents on paper and screens



Taxonomy of work-related reading tasks

- **Skimming:** what is this document about? Will it be useful? Which parts should I read?
 - **Identification:** what type of document is this?
 - **Reminding:** what am I supposed to be doing right now?
- **Searching:** where is the information that helps me answer a question, or find a definition, or make a decision?
 - **Cross-referencing:** where is the information referred to in this other text?
- **Learning:** how can I deeply understand this information?
 - **Listening:** how does this information relate to what's being said?
- **Analysis:** is this information valid?

Observations on the affordances of paper

- Physicality of paper enables richer use of hands
 - Page turning is an automatic skill
 - Use of one hand to save a position while exploring elsewhere in the book
 - Weight / thickness of paper can convey information
- Multiple papers can be laid out in space
 - e.g. two documents for comparison along with a third for notes
- Paper permits rich freeform annotations
 - Underlines (of different weights), asterisks, margin notes

Table 6.1

The Affordances of Paper and of Digital Technologies for Reading

Affordances of Paper

Quick, flexible navigation through and around documents

Reading across more than one document at once

Marking up a document while reading

Interweaving reading and writing

Affordances of Digital Technologies

Storing and accessing large amounts of information

Displaying multimedia documents

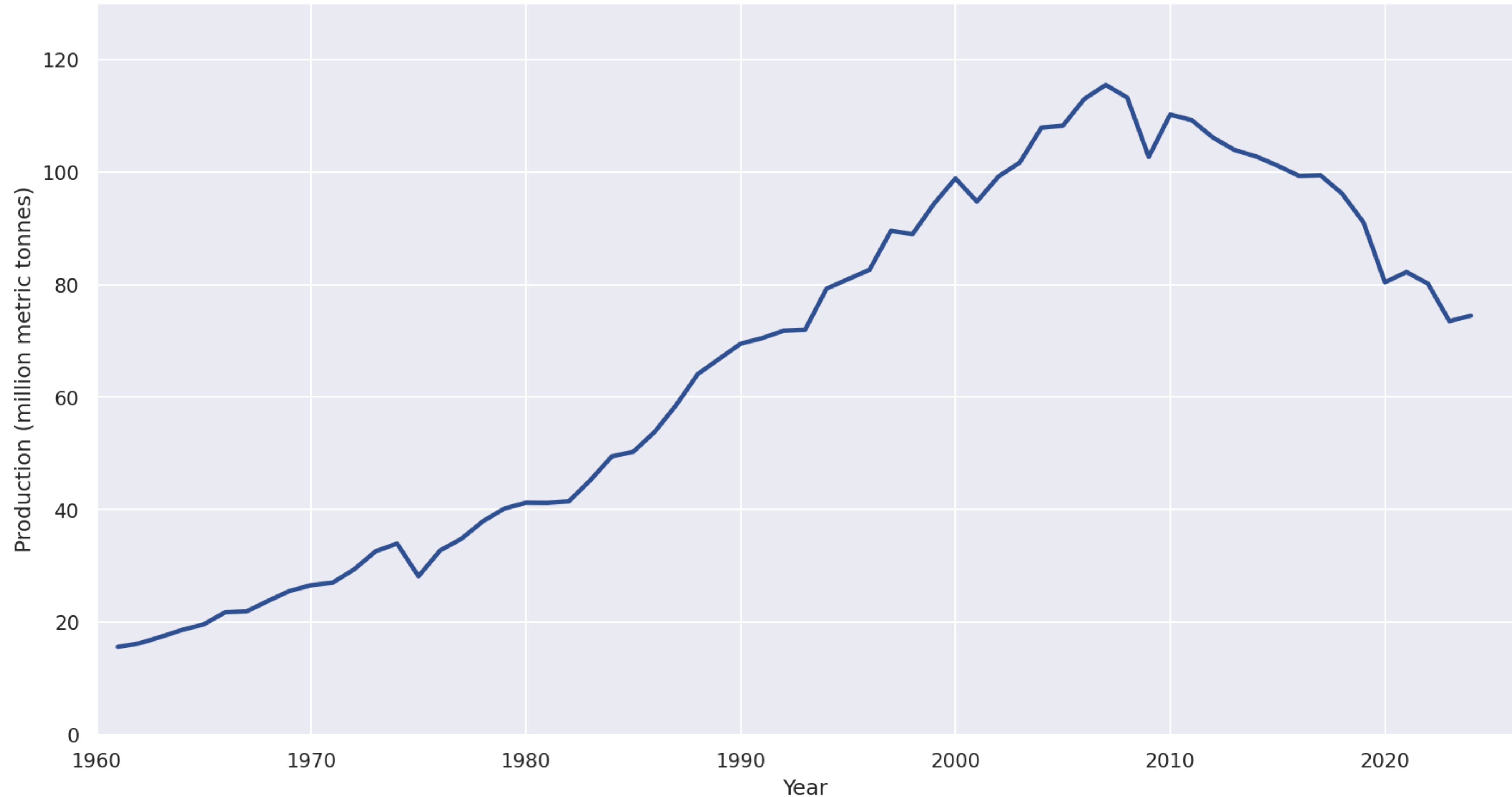
Fast full-text searching

Quick links to related materials

Dynamically modifying or updating content

Paper production for writing/printing has peaked

World Printing & Writing Paper Production, 1961-2024
(Source: FAOSTAT)



The standard for document reading in 2026

PDF file format for paged, fixed-width display

Reading system supports highlighting, comments, table of contents

☆ Sellen and Harper - 20...

+ Create

All toolsEditConvertE-Sign

Find text or tools

ShareAsk AI Assistant

Minutes

2500

2000

1500

1000

500

0

Drafting Own Text

Creating Own Data

Editing Own Text

Editing Own Data

Rev. Another's Text

Rev. Another's Data

Collab. Authoring

Collab. Data An.

Conversations

Meetings

Reading Only

Document Delivery

Note Taking

Formatting Text

Form Filing

Typing Text

Organizing Docs.

Photocopying

Dealing with Mail

Printing

Searching for Docs.

Searching for Info.

Dealing w. Software

Telephone Activity

Thinking & Planning

Responding to Mail

Language Class

No Documents

Paper & Electronic

Electronic Only

Paper Only

Figure 3.3

The activity profile for five administrative staff members.

Administrative assistants were largely involved in transforming paper-based text into electronic form and in the organization and dissemination of information. As it turns out, partly this was because paper was the medium in which the people they supported (the knowledge workers) delivered the information to them in the first place. It was also the medium in which these knowledge workers preferred that information be given back to them, for various reasons we discuss later.

It therefore seemed to us that key to understanding the ubiquity of paper in this organization was understanding how and why the knowledge workers were using it. The facts and figures coming from the diary data

will 2:08 PM

Notably different from activity profile for the economists

Add a reply

Bookmarks

Acknowledgments

1 Introduction

2 What's Wrong with Paper?

3 Paper in Knowledge Work

4 Reading from Paper

5 Paper in Support of Working Together

6 Designing New Technologies

7 The Future of Paper

Notes

References

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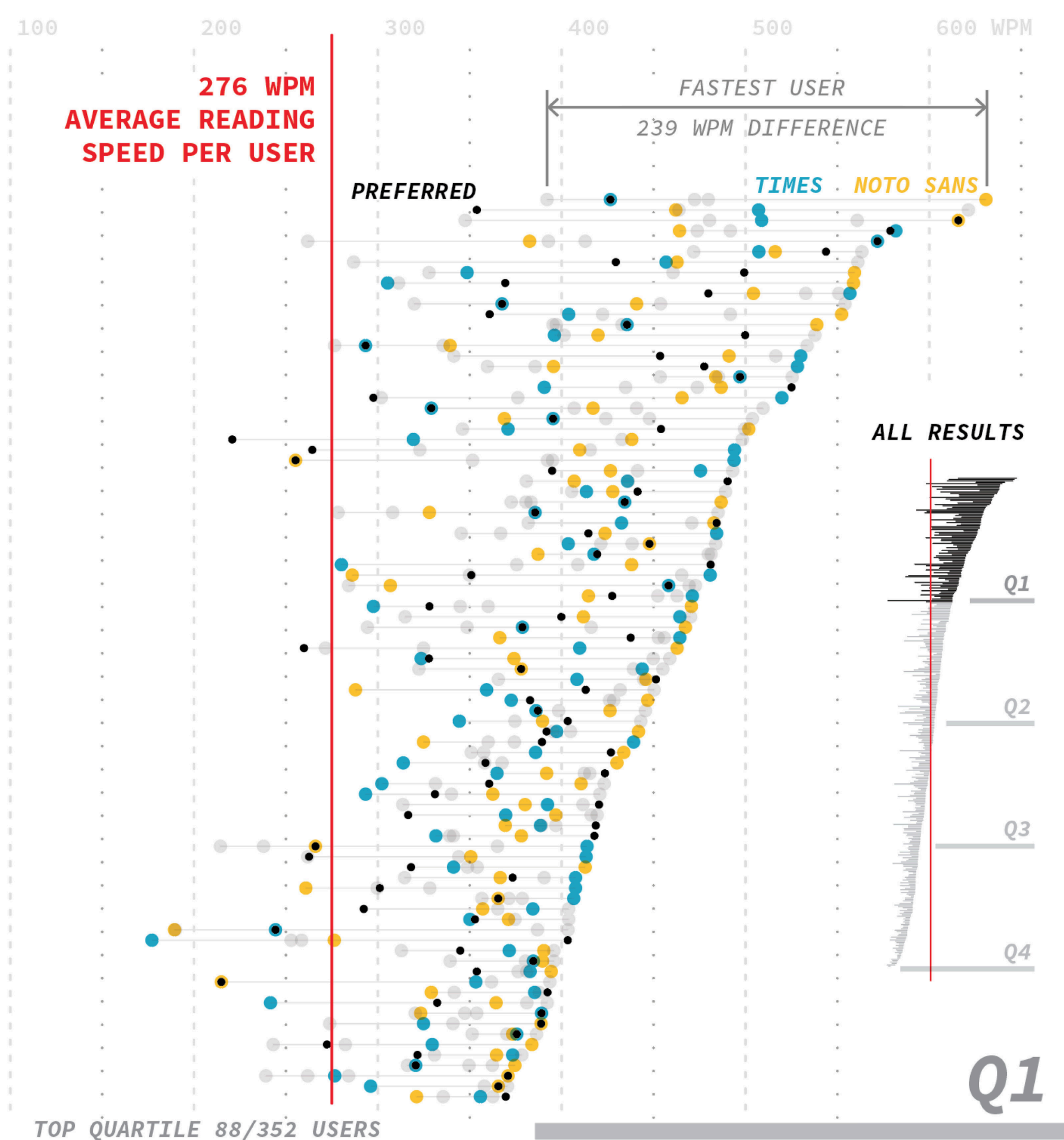
1. Typography

Notable per-person variation in reading speed based on font

Materials: 300-500 word paragraphs of light reading

Times Noto Sans

Procedure: read + comprehension questions, measure WPM



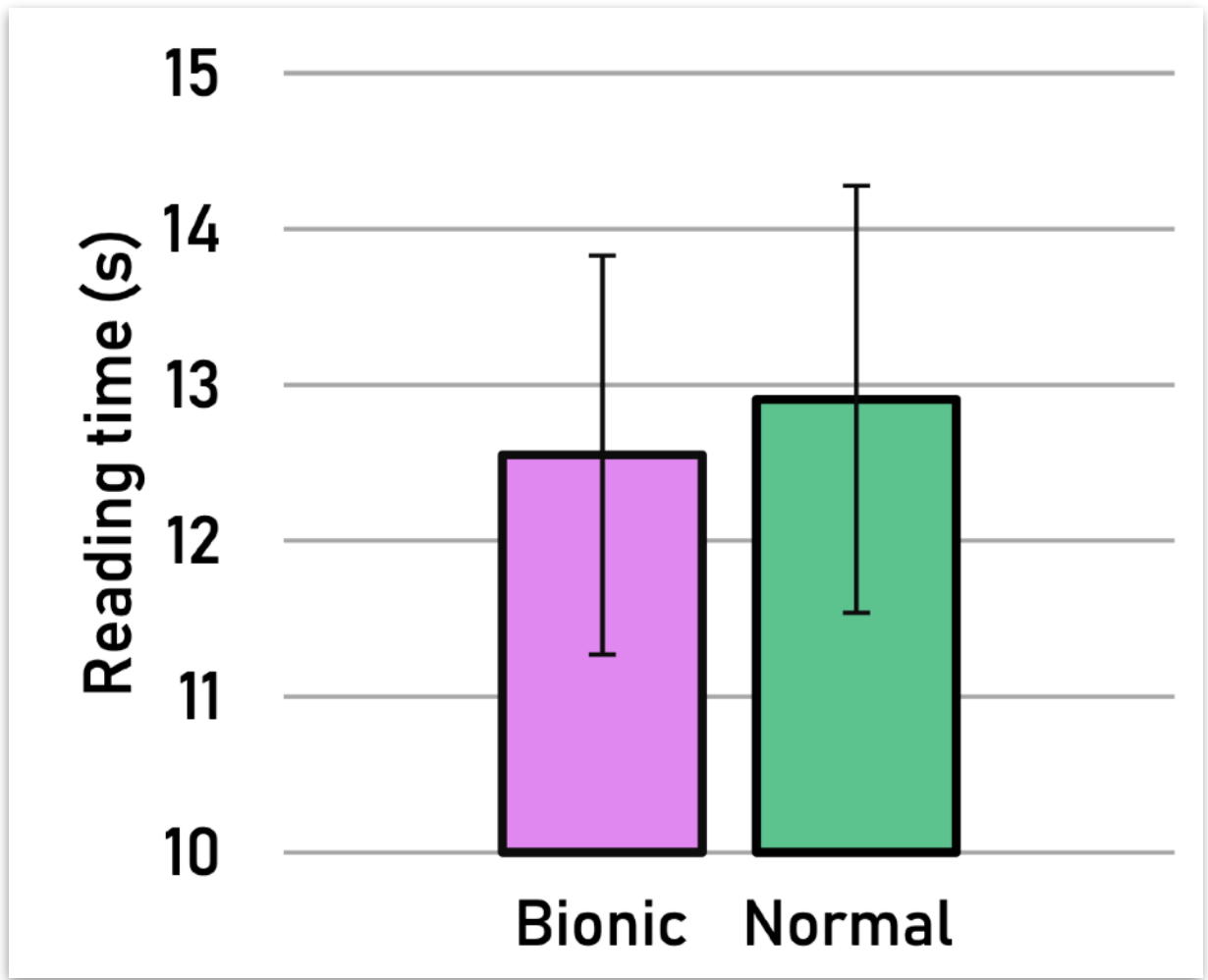
“Bionic reading” doesn’t seem to make a difference

Bionic Reading is a new method facilitating the reading process by guiding the eyes through text with artificial fixation points. As a result, the reader is only focusing on the highlighted initial letters and lets the brain center complete the word. In a digital world dominated by shallow forms of reading, Bionic Reading aims to encourage a more in-depth reading and understanding of written content.

Table 1: Summary speed statistics per font (WPM)

	Bionic	Non-Bionic
Mean	325.3	327.9
Median	294.0	289.6
Standard Deviation	134.6	148.5

Daniel Doyon. “Does Bionic Reading actually work? We timed over 2,000 readers and the results might surprise you” 2022



Joshua Snell. “No, Bionic Reading does not work” 2024

“Beeline reading” doesn’t seem to make a difference

Suffering from screen fatigue? We’re here to help! BeeLine Reader makes reading on-screen easier, faster, and more enjoyable. We use a simple cognitive trick — an eye-guiding color gradient — to pull your eyes through long blocks of text. This helps you read more effectively and maintain your focus better.

Our innovative technology has won social impact awards from The United Nations and Stanford University, and our tools have been adopted by top colleges and universities. Check out our apps below and see how much BeeLine can help you!   

2nd graders read faster w/ Beeline for texts with “long lines and little inter-line spacing”, but slower for texts “optimized for their reading level”

3rd graders read all texts slower w/ Beeline and rated it as less enjoyable and harder to use

Dyslexia fonts do not seem to make a difference

Dyslexia: learning disability that affects reading or writing

The quick red fox jumped
over the lazy brown dog.

OpenDyslexic

The quick red fox jumped
over the lazy brown dog.

Dyslexie

Neither font shows improvement for dyslexic or non-dyslexic children compared to Arial and Times New Roman

Kuster et al. "Dyslexie font does not benefit reading in children with or without dyslexia" 2017

Wery and Diliberto. "The effect of a specialized dyslexia font, OpenDyslexic, on reading rate and accuracy" 2016

2. Layout

E-books provide structural formats for documents

On the Limits of Social-Democratic Societies

At this stage, note simply that in most parts of the world, whether it be social-democratic Europe, the United States, India, or China, inequality has increased since 1980, with a strong rise in the top decile's share of total income and a significant drop in the share of the bottom 50 percent (Fig. 11.1).¹⁰ Within this

PDF - PostScript

```
/Times-Italic findfont 24 scalefont setfont
306 680 moveto
(On the Limits of Social-Democratic
Societies) show
/Times-Roman findfont 18 scalefont setfont
72 620 moveto
(At this stage, note simply that in most
parts of the world, whether it be
social-) show
```

EPUB - XHTML

```
<section>
  <h2>On the Limits of Social-
    Democratic Societies</h2>
  <p>At this stage, note simply
    that in most parts of the
    world, whether it be social-
    democratic Europe, ...</p>
  ...
</section>
```


E-books enable dynamic layout

Fixed layout PDF

Fluid layout EPUB, via Apple Books

492 · THE GREAT TRANSFORMATION OF THE TWENTIETH CENTURY

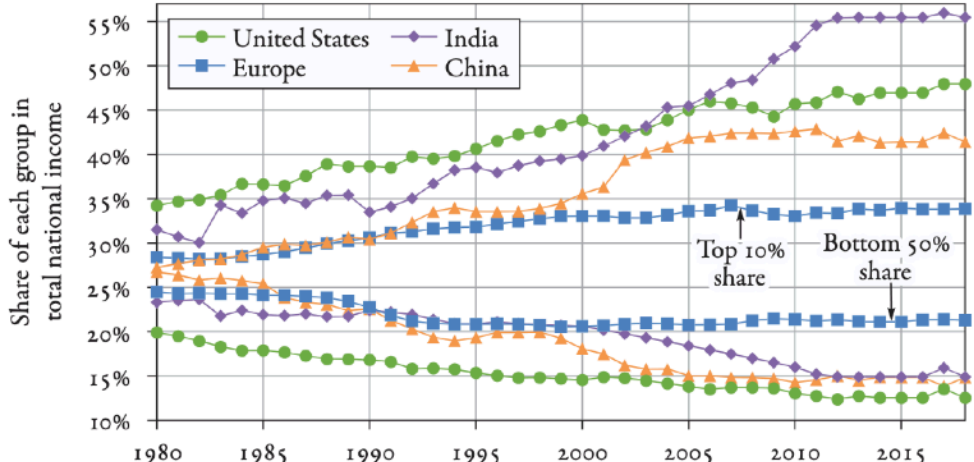


FIG. 11.1. Divergence of top and bottom incomes, 1980–2018

Interpretation: The top decile share increased in all parts of the world. It ranged from 27 to 34 percent in 1980 and from 34 to 56 percent in 2018. The share of the bottom 50 percent decreased: it was between 20 and 27 percent and is now between 12 and 21 percent. The divergence of top and bottom incomes is general, but its amplitude varies with the country: it is greater in India and the United States than in China and Europe (EU). *Sources and series:* piketty.pse.ens.fr/ideology.

stabilization.¹¹ In a context of increasing fiscal and social competition, which European social-democratic governments themselves did much to create and which has created many problems for African, Asian, and Latin American countries seeking to develop viable social models, it is not out of the question that the inegalitarian trend of the post-1980 period may grow stronger in the future. In addition, most of the countries of the Old Continent have had to contend with growing nationalist and anti-immigrant sentiment since 2000. Clearly, European social democracy cannot afford to rest on its laurels.

Furthermore, the egalitarian character of the period 1950–1980 should not be exaggerated. For example, if we compare the case of France (which is fairly representative of Western Europe) and the United States, we find that the share of national income going to the bottom 50 percent has always been significantly smaller than the share going to the top 10 percent (Fig. 11.2). At the turn of the twentieth century, the top decile claimed 50–55 percent of total income, and the bottom five deciles had gotten about one-quarter of that (around 13 percent of total income). Since the first group is by definition one-fifth the size of the second, this means that the average income of the top decile was twenty times

11. See Figs. 10.1–10.2.

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Capital and Ideology

lems for African, Asian, and Latin American countries seeking to develop viable social models, it is not out of the question that the inegalitarian trend of the post-1980 period may grow stronger in the future. In addition, most of the countries of the Old Continent have had to contend with growing nationalist and anti-immigrant sentiment since 2000. Clearly, European social democracy cannot afford to rest on its laurels.

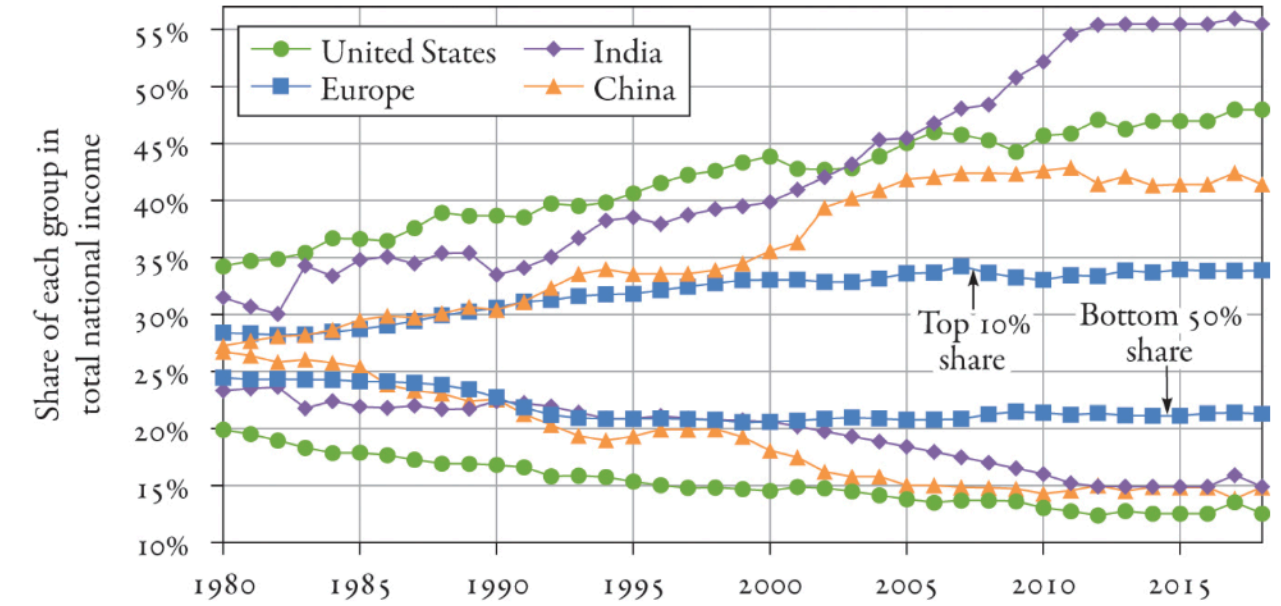


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bottom half of the US population today (and that the gap between the United States and Europe is due to the gap prior to taxes and transfers).

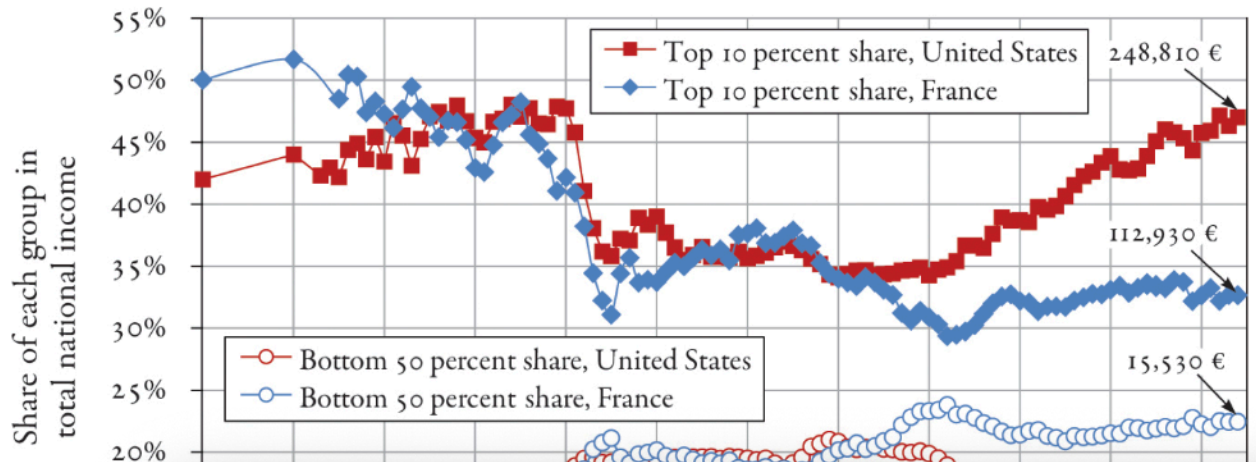


FIG. 11.2. Bottom

Interpretation: In France (and Europe) the bottom 50 percent still received a much smaller share of national income than the top 10 percent. Our first private ownership society was a regional, state-owned

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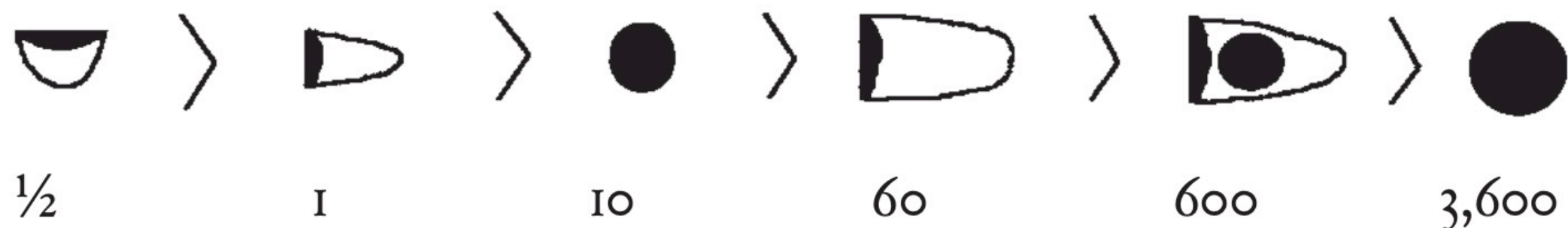
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Layout quality depends on the reading system

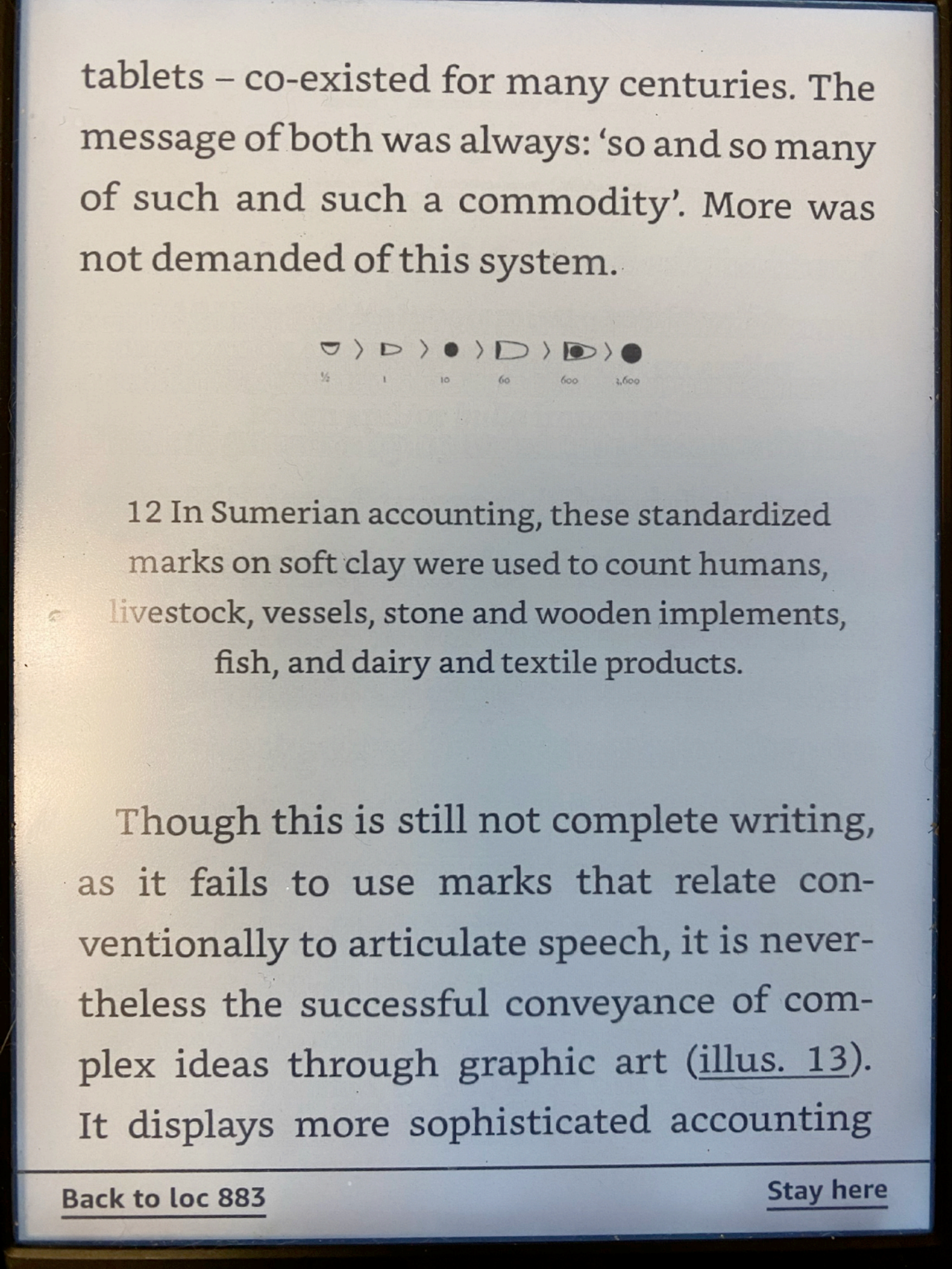
Fixed layout on laptop

Dating to c. 3300 BC from Uruk on the lower Euphrates between Babylon and the Persian Gulf, the earliest of all clay tablets is only one step up from the *bullæ* system, still comprising a system of numerals and (perhaps standardized, stylized) pictograms identifying commodities (illus. 11). In one system of accounting (there were several), numerals were made by pressing the round end of a reed stylus vertically into the clay (full hole = 10), at an angle left to right (hole with cavity = 5), or a number of other possibilities to signify multiples of these. The smallest accounting unit was made by impressing the edge of



12 In Sumerian accounting, these standardized marks on soft clay were used to count humans, livestock, vessels, stone and wooden implements, fish, and dairy and textile products.

Fluid layout on Kindle



Other unresolved questions in e-books

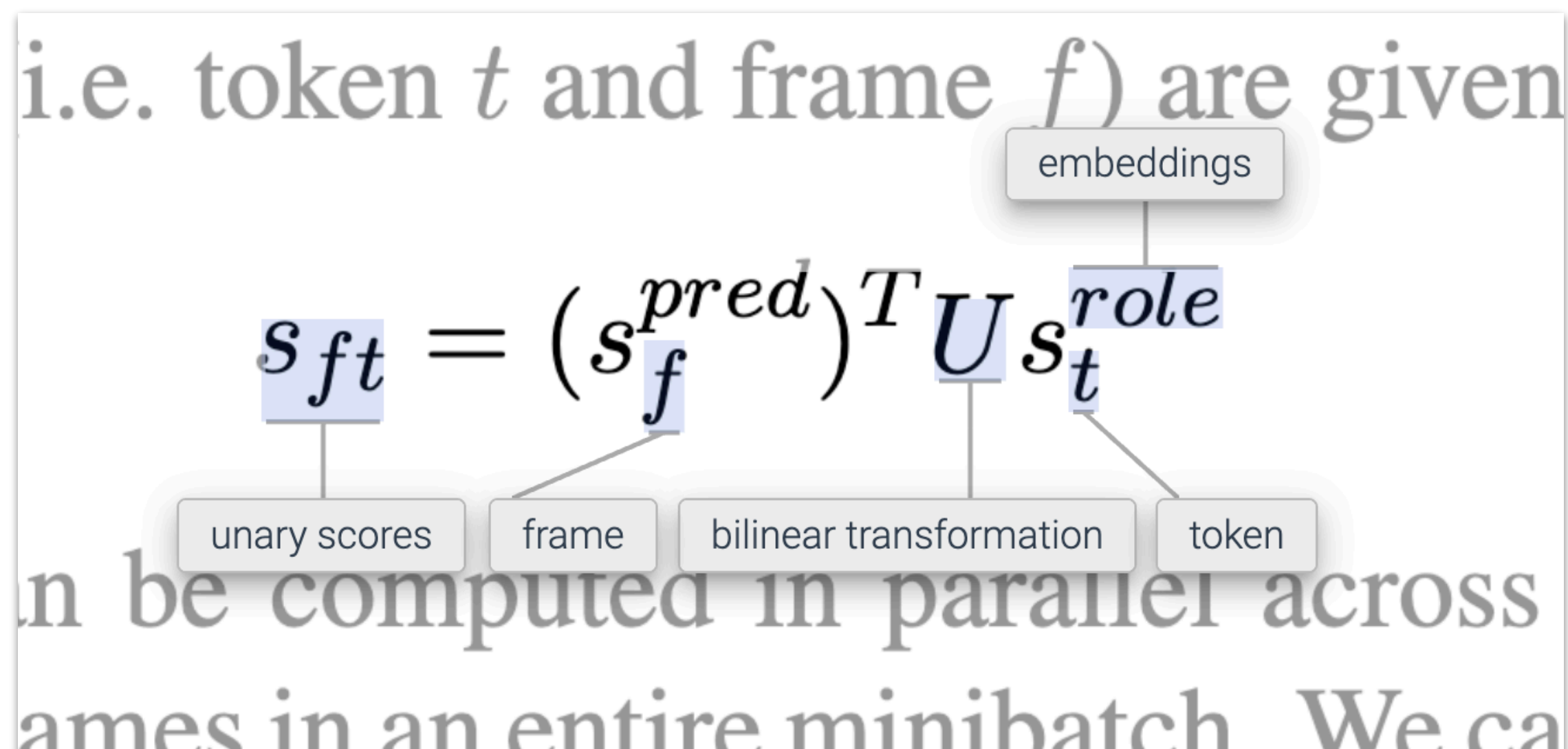
- What is a good system of stable locators for a text?
 - Page numbers only make sense for a fixed layout!
 - Kindle has an opaque system of page “locations”
 - US legal code operates on hierarchy: “8 U.S.C. § 1101(a)(15)(H)(i)(b)”
- How to handle figure placement and multi-column layouts?
 - Esp. in infinite-scroll views
- What’s the best way to typeset source code???

3. Interaction

Context on-demand for terms, references, cites

The screenshot shows a Wikipedia article titled "Mitochondrion". A tooltip is displayed over the text "adenosine triphosphate (ATP)", showing its chemical structure and a brief description: "Adenosine triphosphate (ATP) is a nucleic acid that provides energy to drive and support many processes in living cells, such as muscle contraction, nerve impulse propagation, condensate dissolution, and chemical synthesis. Found in all known forms of life, ATP is often referred to as the".

"Mitochondrion." Wikipedia 2023



Head et al. "Augmenting Scientific Papers with Just-in-Time, Position-Sensitive Definitions of Terms and Symbols" 2021

The screenshot shows a document with a vector product equation. A tooltip is displayed over the text "Equation (4.9)", showing the equation: $(\mathbf{u} + \mathbf{v}) \times (\mathbf{u} - \mathbf{v}) \stackrel{(2,4)}{=} (\mathbf{u} + \mathbf{v}) \times \mathbf{u} - (\mathbf{u} + \mathbf{v}) \times \mathbf{v} \stackrel{(3)}{=} \underbrace{\mathbf{u} \times \mathbf{u}}_{=0} + \mathbf{v} \times \mathbf{u} - \mathbf{u} \times \mathbf{v} - \underbrace{\mathbf{v} \times \mathbf{v}}_{=0} \stackrel{(1)}{=} -2\mathbf{u} \times \mathbf{v}.$

Ström et al. "Immersive Linear Algebra." 2020

The screenshot shows a document with a text snippet. A tooltip is displayed over the text "Deep Speech: Scaling up end-to-end speech recognition", showing the paper's title, authors (Awni Y. Hannun, Carl Case, +8 authors, A. Ng), and a brief description: "TLDR Deep Speech, a state-of-the-art speech recognition system developed using end-to-end deep learning, outperforms previously published results on the widely studied Switchboard Hub5'00, achieving 16.0% error on the full test set. Expand".

Lo et al. "The Semantic Reader Project: Augmenting Scholarly Documents through AI-Powered Interactive Reading Interfaces" 2023

Study: participants
~25% faster at
answering simple
comprehension
questions

Keeping text and figures in sync

Define a product to sell

Always keep sensitive information about your product inventory, such as price and availability, on your server to prevent customer manipulation from the client. Define product information when you create the Checkout Session using [predefined price IDs](#) or on the fly with [price_data API](#).

One-time

Recurring

Name

Sunglasses, premium plan, etc.

Price

\$ 0.00

USD ↕

+ Create test product

More options ↗

Server

Choose a mode

To handle different transaction types, adjust the `mode` parameter. For one-time payments, use `payment`. To initiate recurring payments with [subscriptions](#), switch the `mode` to `subscription`. And for [setting up future payments](#), set the `mode` to `setup`.

Server

Supply success URL

Preview

server.rb

checkout.html

success.html

cancel.html

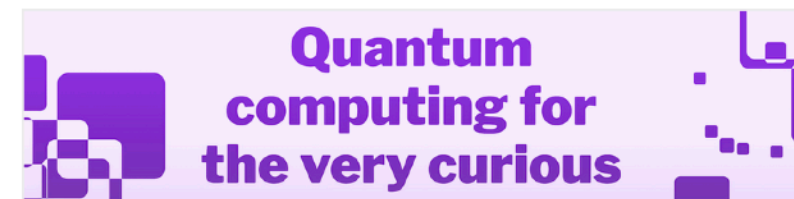
Download ↴

```
1 require 'stripe'
2 require 'sinatra'
3
4 # This test secret API key is a placeholder. Don't include personal details in requests with this key
5 # To see your test secret API key embedded in code samples, sign in to your Stripe account.
6 # You can also find your test secret API key at https://dashboard.stripe.com/test/apikeys.
7 Stripe.api_key = 'sk_test_51SxEnrLaiuIBIIhfeCHdoHZFZJq70qsVhSrrmqsdNLW6d7i8Aggg1V963aBj5DCXrNDojhqau'
8
9 set :static, true
10 set :port, 4242
11
12 YOUR_DOMAIN = 'http://localhost:4242'
13
14 post '/create-checkout-session' do
15   content_type 'application/json'
16
17   session = Stripe::Checkout::Session.create({
18     line_items: [{
19       # Provide the exact Price ID (for example, price_1234) of the product you want to sell
20       price: '{{PRICE_ID}}',
21       quantity: 1,
22     }],
23     mode: 'payment',
24     success_url: YOUR_DOMAIN + '/success.html',
25   })
26   redirect session.url, 303
27 end
```

<https://docs.stripe.com/checkout/quickstart>

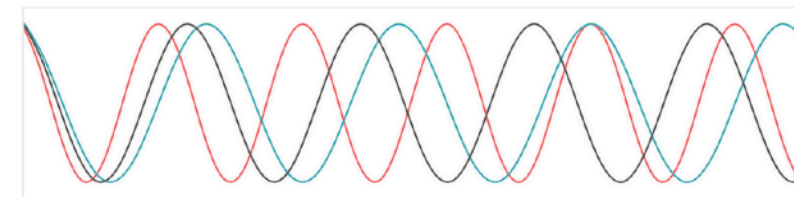
“Explorable explanations” leverage interaction and simulation to explain concepts

via <https://explorables.es>



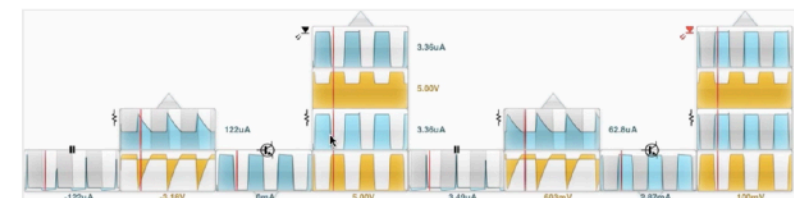
★ Quantum Computing for the Very Curious physics programming

an introduction with embedded Spaced Repetition



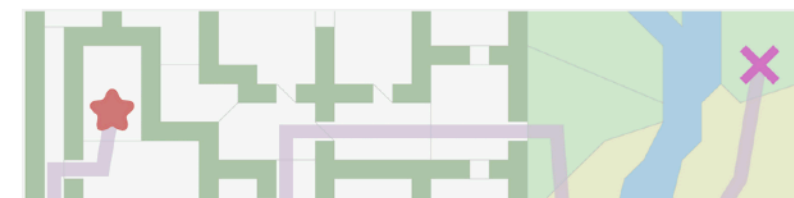
★ LightNote.co art

a playful introduction to music theory



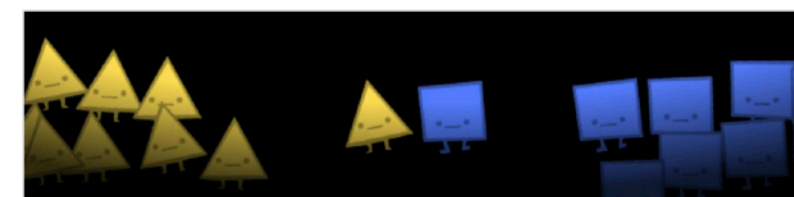
★ Media For Thinking The Unthinkable further reading

an hour-long talk on tools that re-define how we think



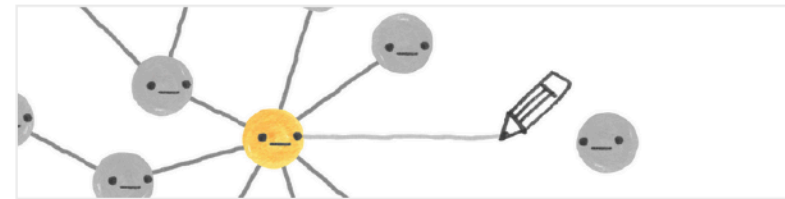
★ Introduction to A* programming

how to program pathfinding for your game



★ Parable of the Polygons social science

an interactive story about how we divide ourselves, from the bottom up

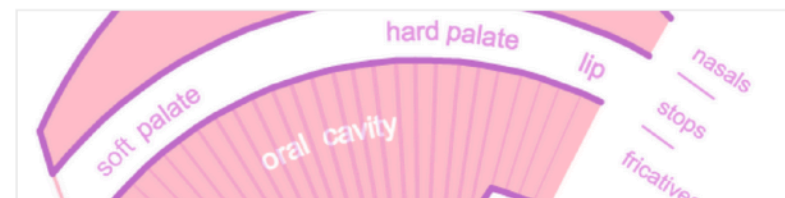


★ The Wisdom and/or Madness of Crowds social science

an interactive guide to human networks



★ An Interactive Introduction to Fourier Transforms math



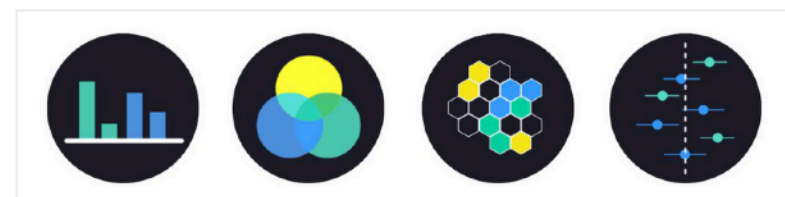
★ Pink Trombone misc

a horrifying toy that shows how the human voice works



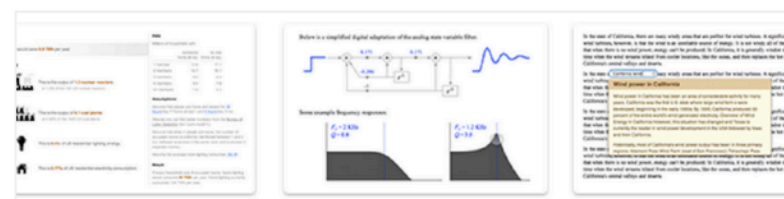
★ Fireflies biology

a small, serene simulation of self-synchronization



★ Seeing Theory math

a visual introduction to probability and stats



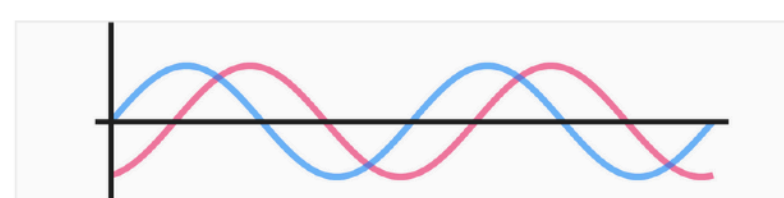
★ Explorable Explanations further reading

the 2011 essay that coined the phrase 'Explorable Explanation'



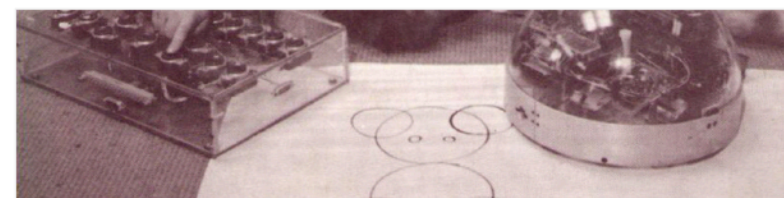
★ Gears math physics

a very, very deep dive into gears



★ Let's Learn About Waveforms math physics

an interactive guide to waves & harmonics



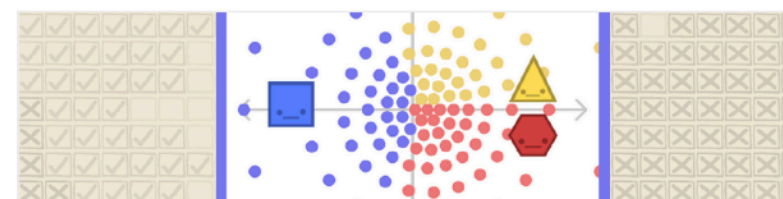
★ Mindstorms further reading

the classic 1980 book on how children learn, through play



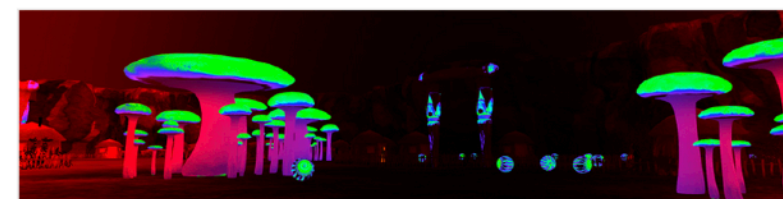
★ Observable tools

a better way to code, discover, and communicate



★ To Build A Better Ballot civics

an interactive guide to alternative voting systems



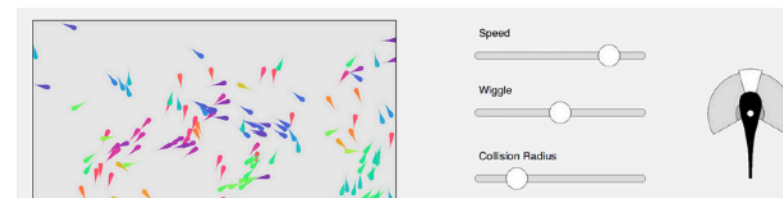
★ A Slower Speed of Light physics

a game that shows what moving near light-speed looks like



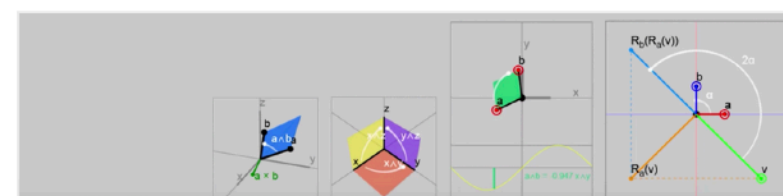
★ Virus: The Beauty of the Beast biology

an interactive documentary on the mathematical majesty of viruses



★ Complexity Explorables biology math physics

explorations of complex systems



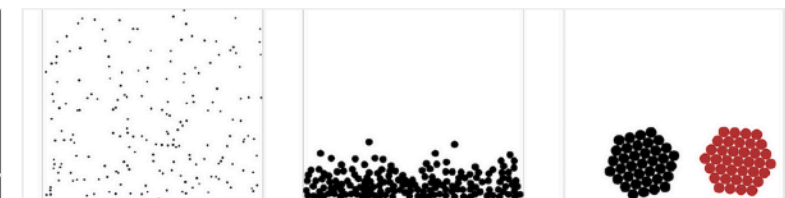
★ Let's Remove Quaternions From Every 3D Engine math programming

an introduction to Geometric Algebra



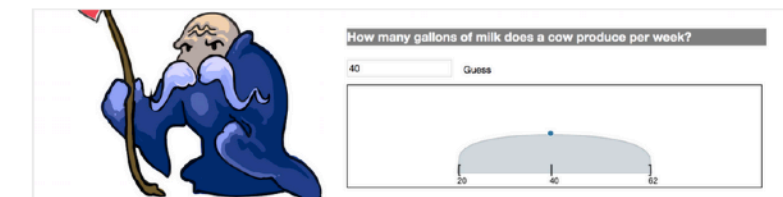
★ What Happens Next? biology

covid-19 futures explained, with playable simulations



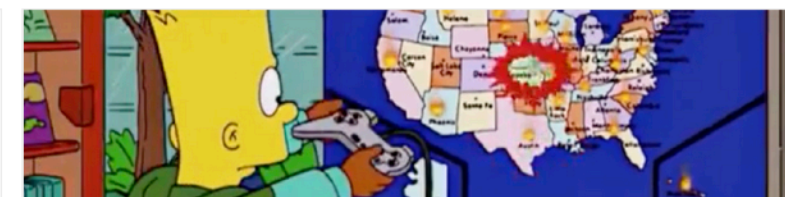
★ Many Tiny Things physics

a playful guide to statistical physics



★ Adventures in Cognitive Biases psychology

a game to reduce overconfidence bias & train Bayesian thinking



★ The 2018 Explorables Jam misc

a hackathon to explain an idea through play!



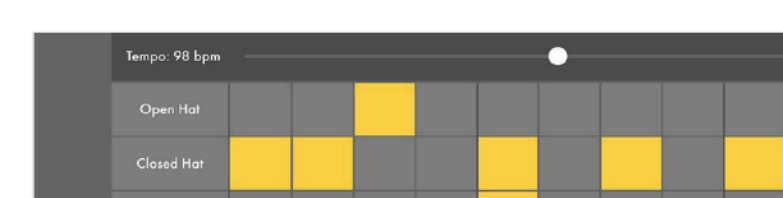
★ Back to the Future of Handwriting Recognition programming

an interactive history of handwriting recognition software



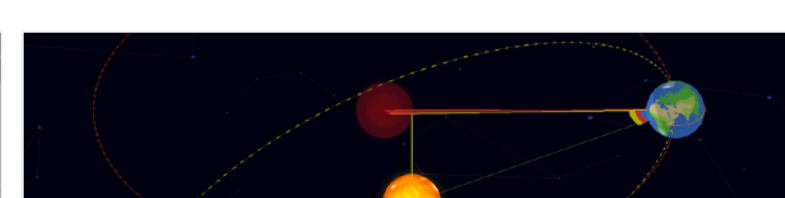
★ Trigonometry for Games (Making a Homing Rocket) art math programming

an interactive gamedev tutorial



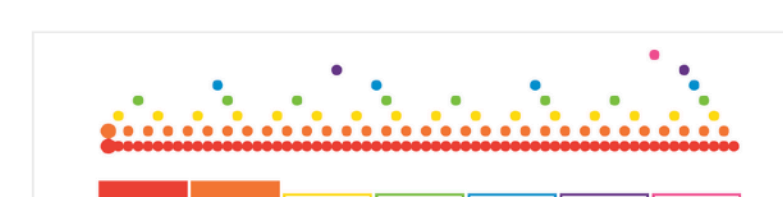
★ Learning Music art

an interactive tour to making music



★ What Is A Day? physics

a simulation-with-narration about what, really, is a "day"?



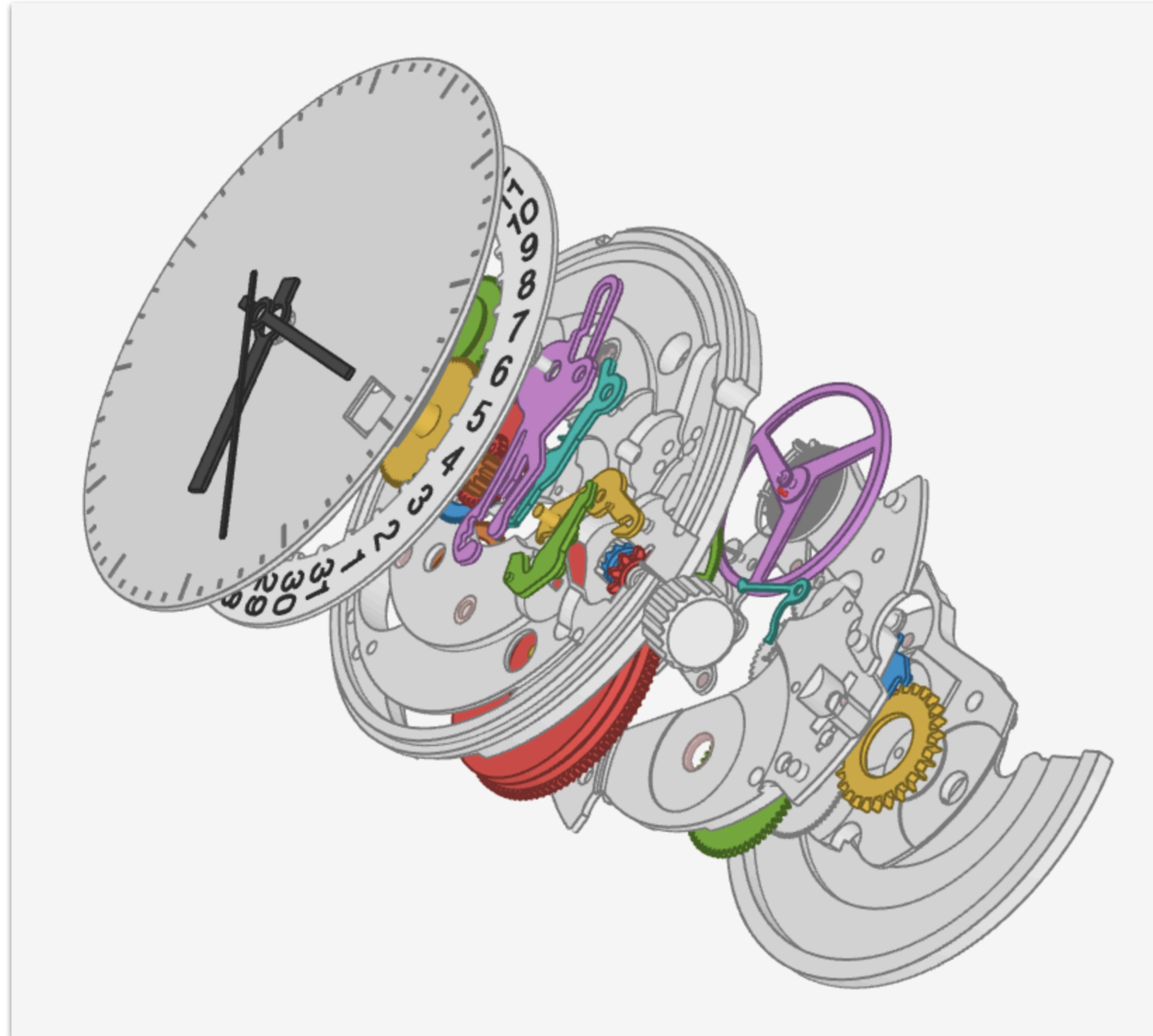
★ How To Remember Anything Forever-ish psychology

an interactive comic on spaced repetition



★ 4D Toys math

an interactive toy for 4D children



<https://ciechanow.ski/mechanical-watch/>

Ten Brighter Ideas

- 1
- Conservation is key and simply achieved. Start by
 - turning off lights
 - unplugging electrical equipment when not in use

- 2
- If every U.S. household installed just one compact fluorescent light bulb, it would displace the electricity provided by one nuclear reactor. 1=1!

Twenty compact fluorescents in every household would displace the need for at least 25% of all U.S. reactors.

- 3
- Updating heating, lighting, cooling and other electrical appliances with energy-efficient models can
 - save more energy than all operating U.S. reactors produce annually
 - reduce home electricity use by at least 20%.

- 4
- Energy efficiency is the cheapest and fastest way to reduce carbon emissions.

It is least seven times more cost-effective at displacing carbon than nuclear power.

Premise

Suppose 100% of US households replaced 1 bulb at random with a compact fluorescent.

Result

This would save 11.6 TWh per year.

Context



This is the output of 1.5 nuclear reactors.
or 1.4% of the 104 US nuclear reactors.



This is the output of 9.5 coal plants.
or 0.66% of the 1445 US coal plants.



This is 11% of US residential lighting energy.

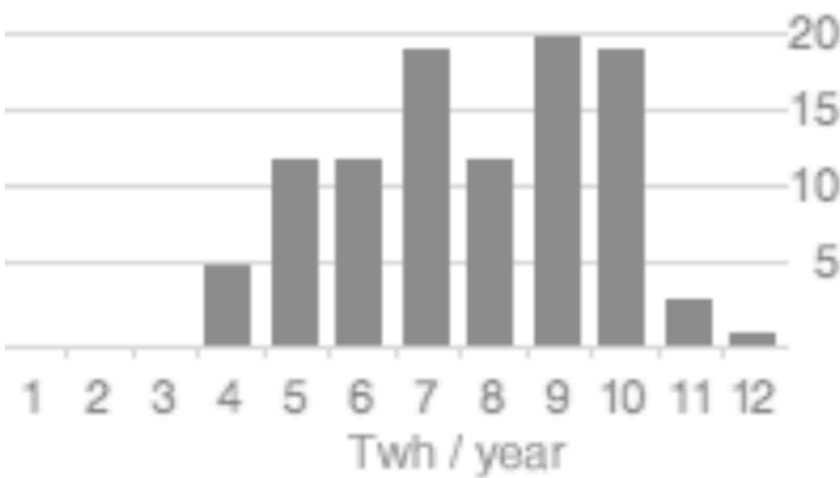


This is 0.91% of US residential electricity consumption.

Nuclear Power

Assuming 7.9 TWh per reactor, the saved 11.6 TWh is equivalent to 1.5 nuclear reactors.

An average nuclear reactor produces 7.7 TWh / year.
Number of reactors by power output:



Cost

Annual cost of 1.5 nuclear plants:

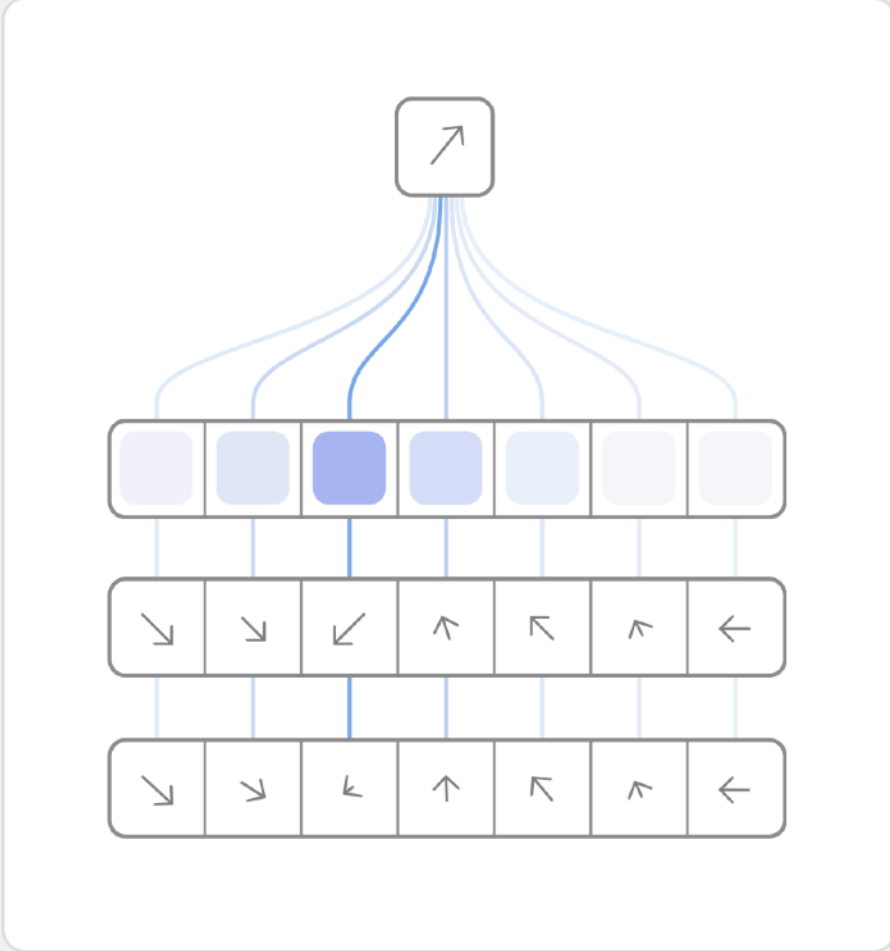
\$276 million for construction (amortized)
\$140 million for operation
\$63 million for fuel
\$479 million total per year

This is \$1.56 per year per person.

Waste

1.5 nuclear plants produce 31.7 metric tons of radioactive waste per year, which will eventually require long-term storage.

Interactive articles require significant technical and pedagogic skill, plus time



 [Reactive diagrams](#) allow for a type of communication not possible in static mediums. Hover over this diagram to see how a neural turing machine shifts its attention over its old memory values to create new values.

A modern medium for presenting research

The web is a powerful medium to share new ways of thinking. Over the last few years we've [seen many imaginative examples of such work](#). But traditional academic publishing remains focused on the PDF, which prevents this sort of communication.

“We don’t believe that having a venue is the primary bottleneck to authors producing more Distill-style articles. Instead, we believe the primary bottleneck is the amount of effort it takes to produce these articles and the unusual combination of scientific and design expertise required.”

Recent languages try to reduce the authoring work

Quarto

To place figures in the margin you can use the `**Quarto**` chunk option ``column: margin``. For example:

```
```{r}
#| label: fig-main
#| fig-cap: "A figure in the main
column."
ggplot(diamonds, aes(cut, price)) +
 geom_boxplot()
```

In `@fig-main`, `N={r} nrow(diamonds)`

<https://quarto.org/>

## Living Papers

```
``` js { hide=true }
confidence_level = 50;
---
alpha_level = 1 - confidence_level
  / 100;
```
```

Dots indicate sample means, while error bars are

```
[:option-text:] {
 options=[50,68,80,90,95,99,99.9]
 suffix="%" span=5
 bind=confidence_level
}
```

confidence intervals ...

<https://idl.uw.edu/living-papers-paper/>

# Are explorables for pedagogy or persuasion?

“the term “explorable explanation” [...] has now been applied so broadly that it seems to mean “any article with interactive pictures” [...]

However, [most explorables] are pedagogical, and that's not really what I was going for here. What I meant by “explorable explanation” was more like, “a written *argument* whose assertions are backed by explorable computational models, whose *facts, assumptions, and calculations* are all visible and editable”.

The author's role here is not just to teach, but to convince. The reader's role is not to believe, but to critically evaluate, rebut, and come to a broad understanding. The reader rebuts by modifying the models.”



## **4. Note-taking**

# Most note apps offer the same standard features



Goodnotes



OneNote



Notability



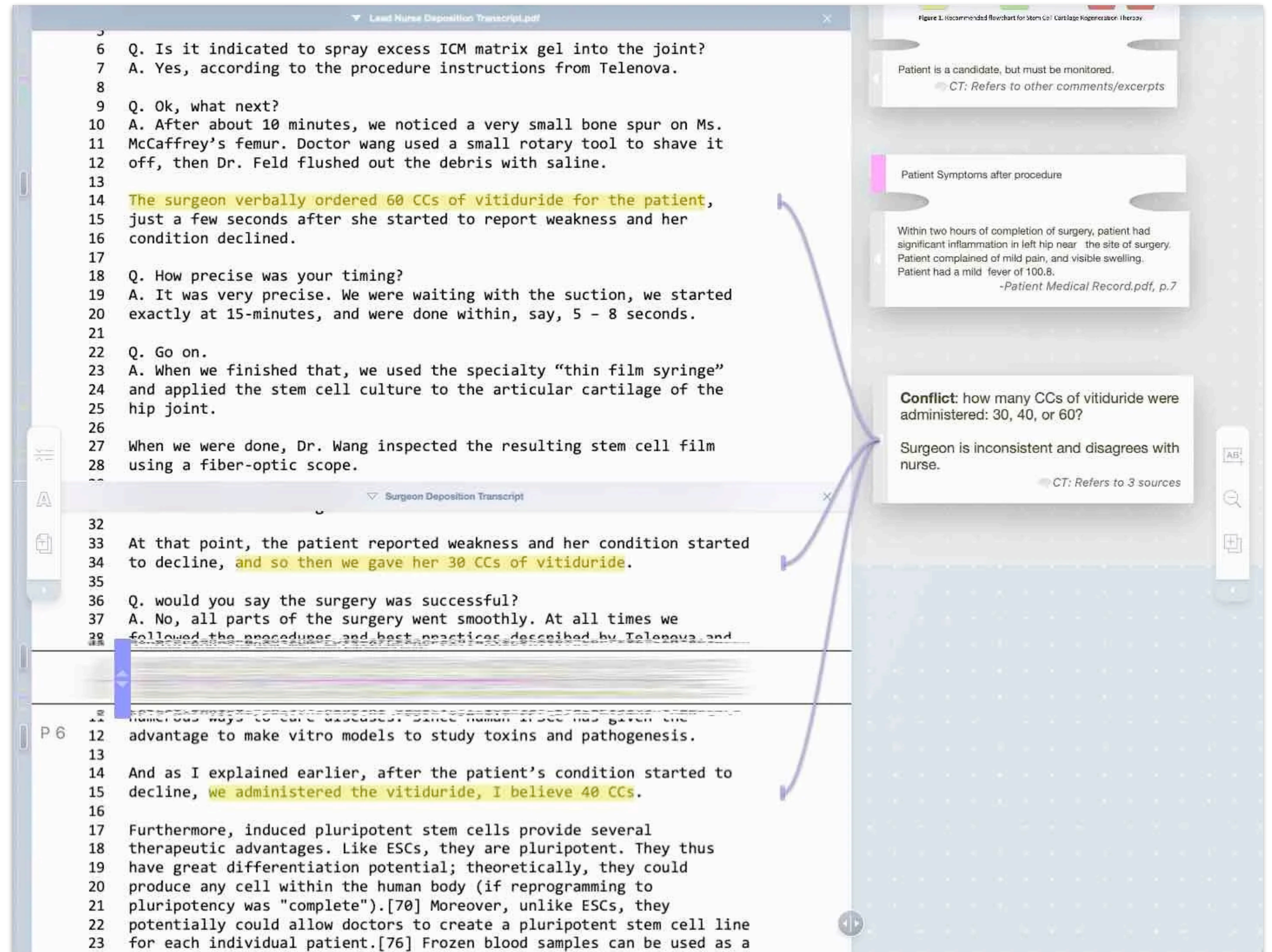
Noteful

- Highlighting
- Underlining
- Freehand drawing
- Text notes
  - Attached to highlight
  - In a sticky note



# LiquidText provides a canvas for infinite margins

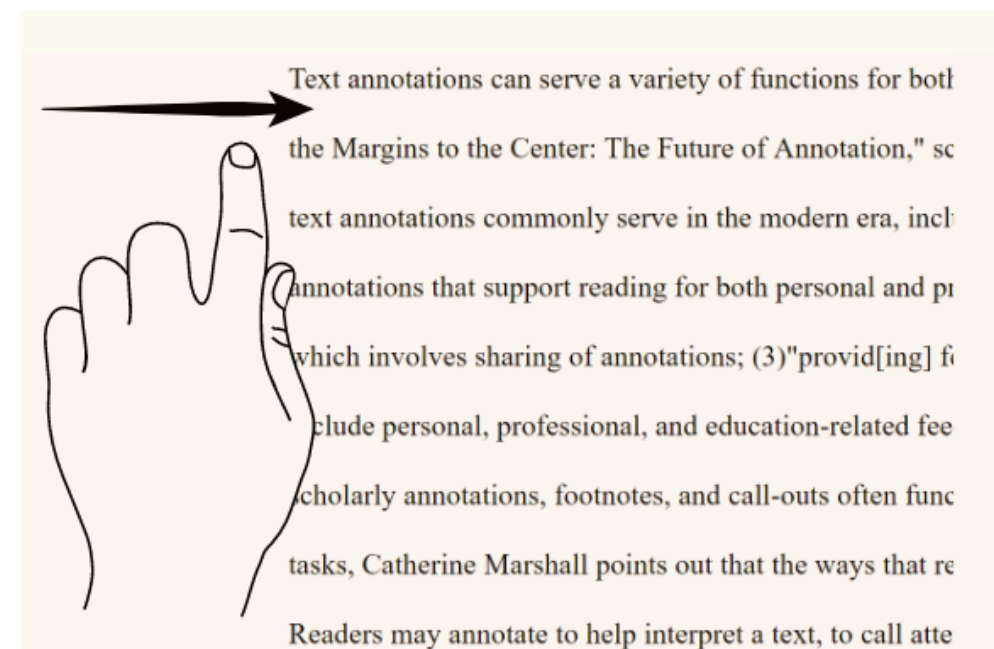
- Extract text onto canvas
- Link text to multiple parts of a document
- Collapse to compare disparate pages



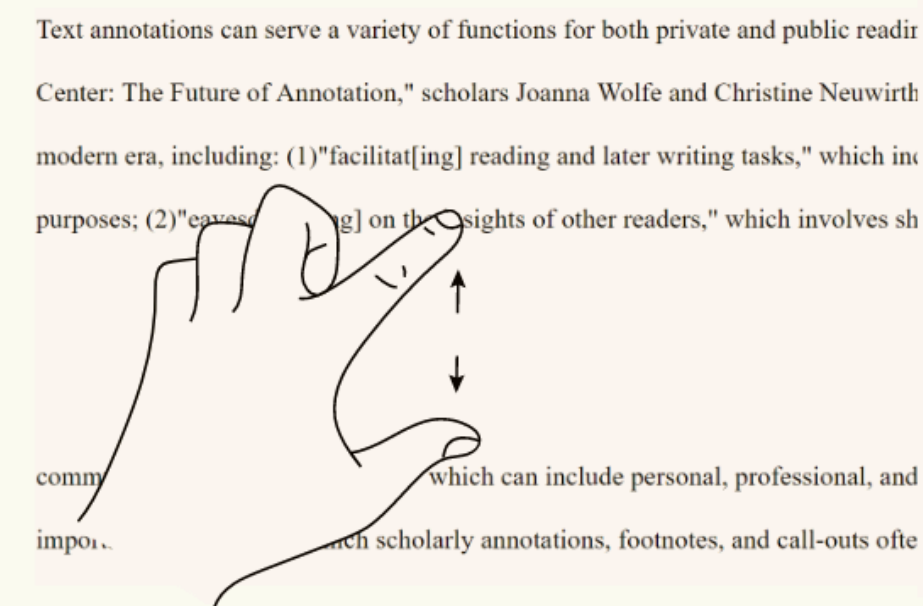


# Making space for notes on text

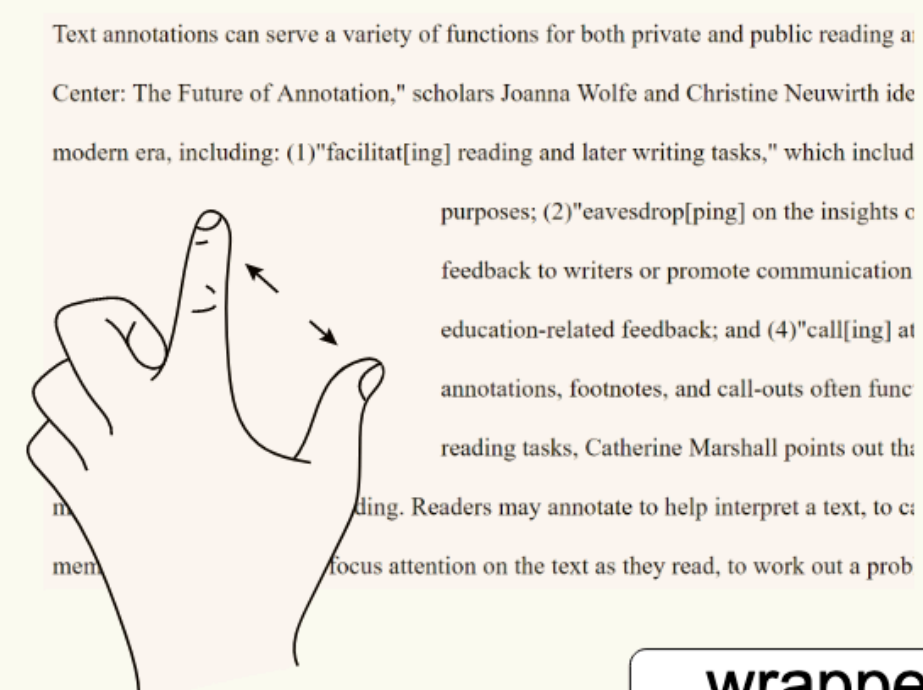
## TOUCH-BASED



side of paragraph

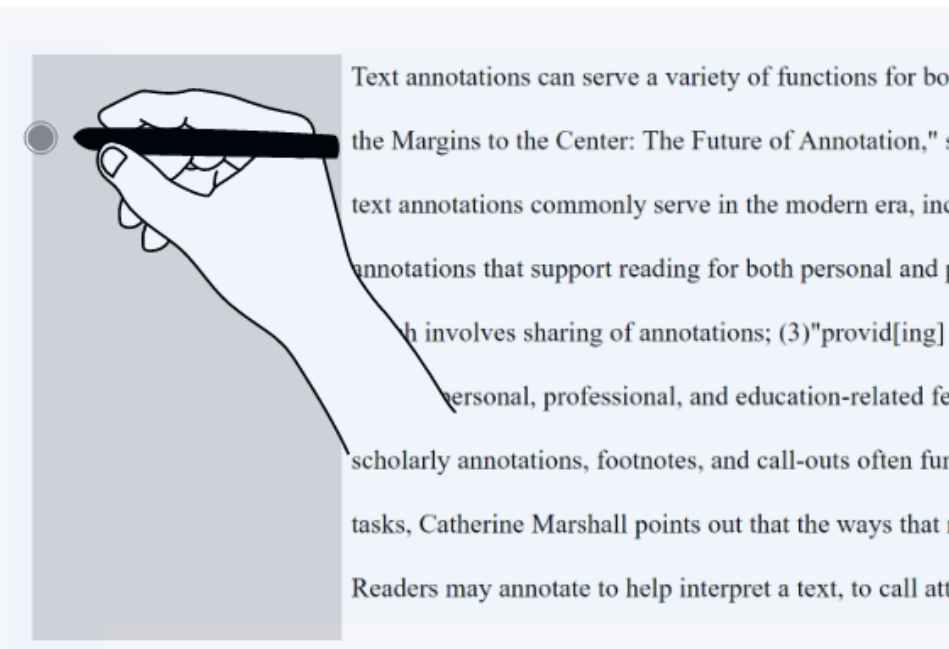
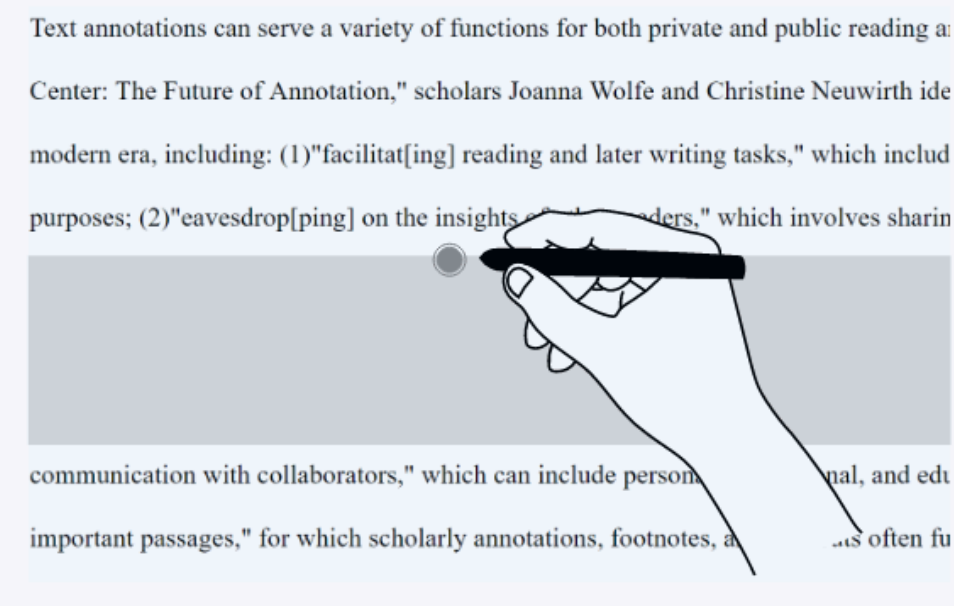
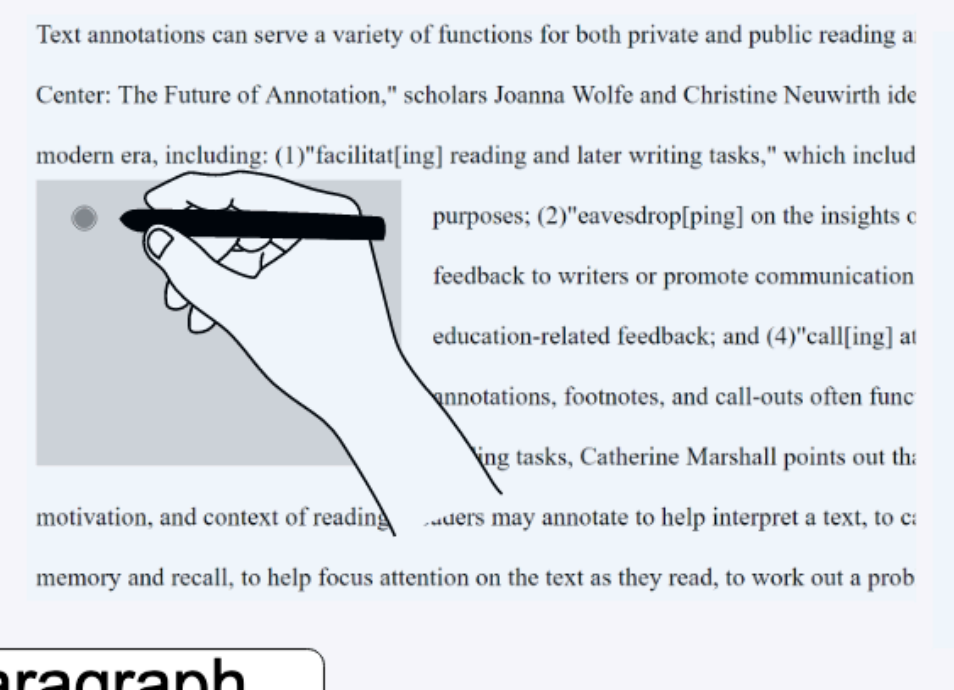


between lines



wrapped in paragraph

## PEN-BASED



- Key ideas: where annotations are added, when does the user indicate which space to use

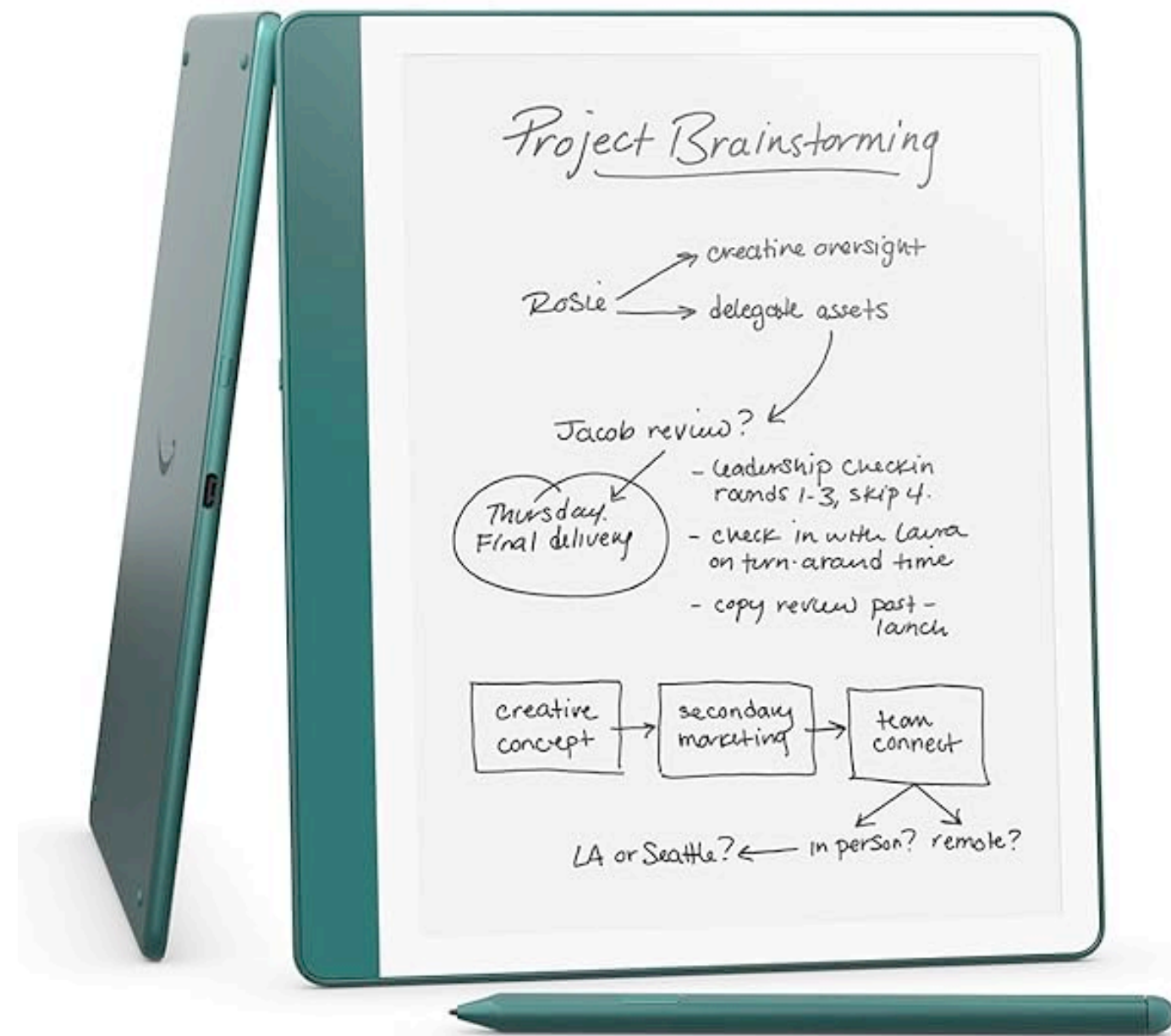
- Study: all annotation locations useful, with between lines and wrapped in paragraph most used

- Adopted by Kindle Scribe



# **5. Hardware**

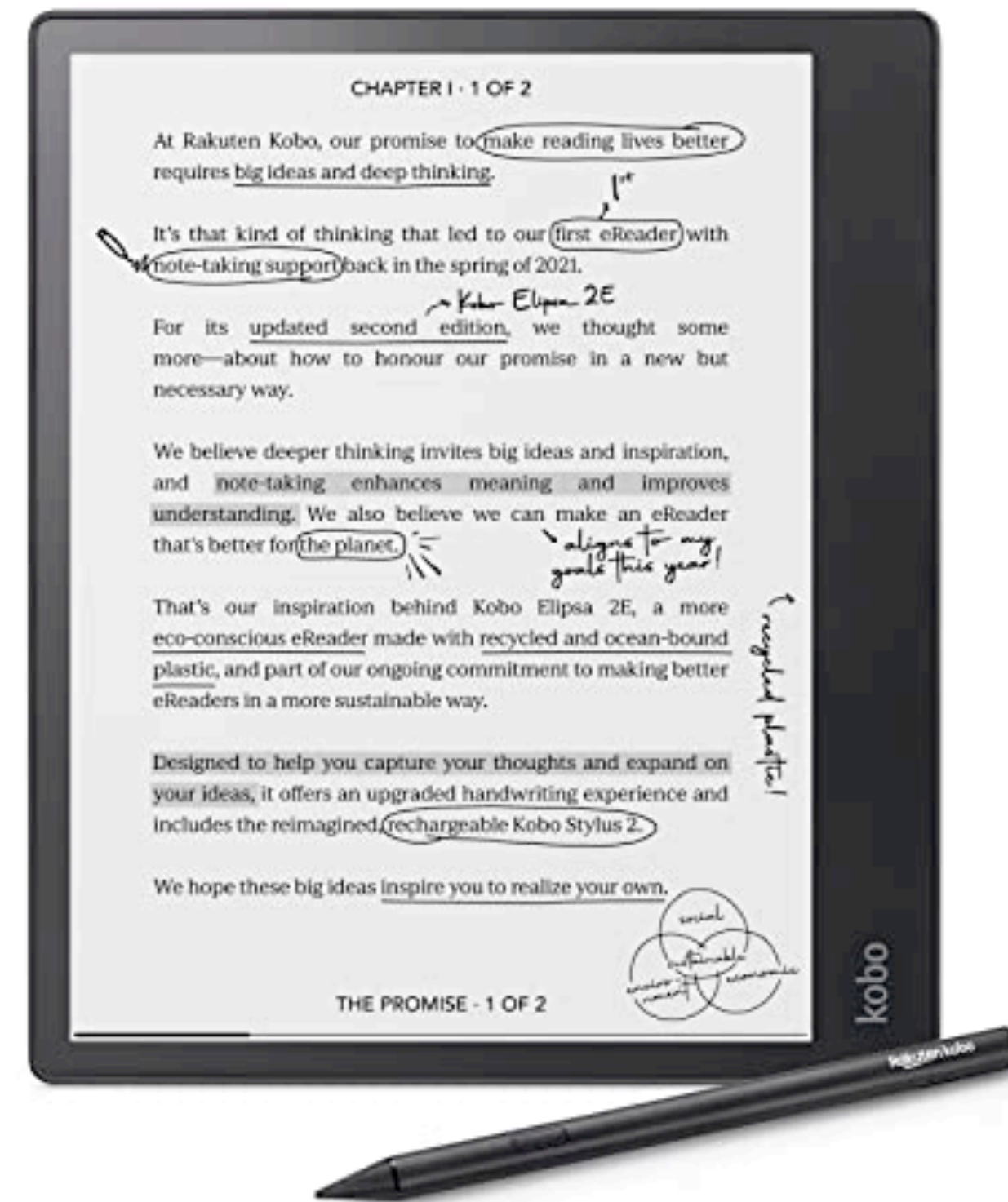
# E-paper tablets became popular in the last decade



Kindle Scribe



reMarkable



Kobo Elipsa

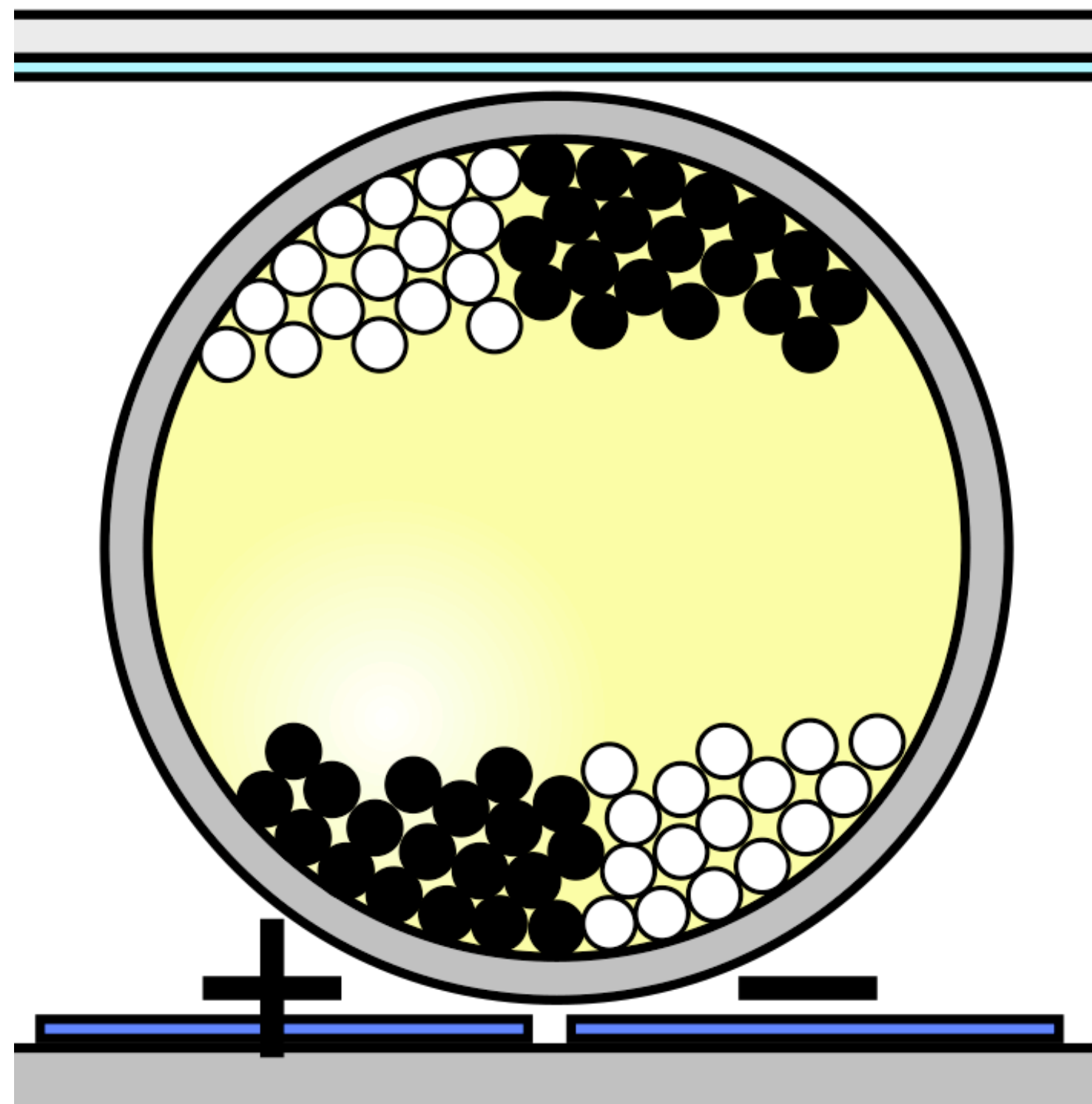


Daylight

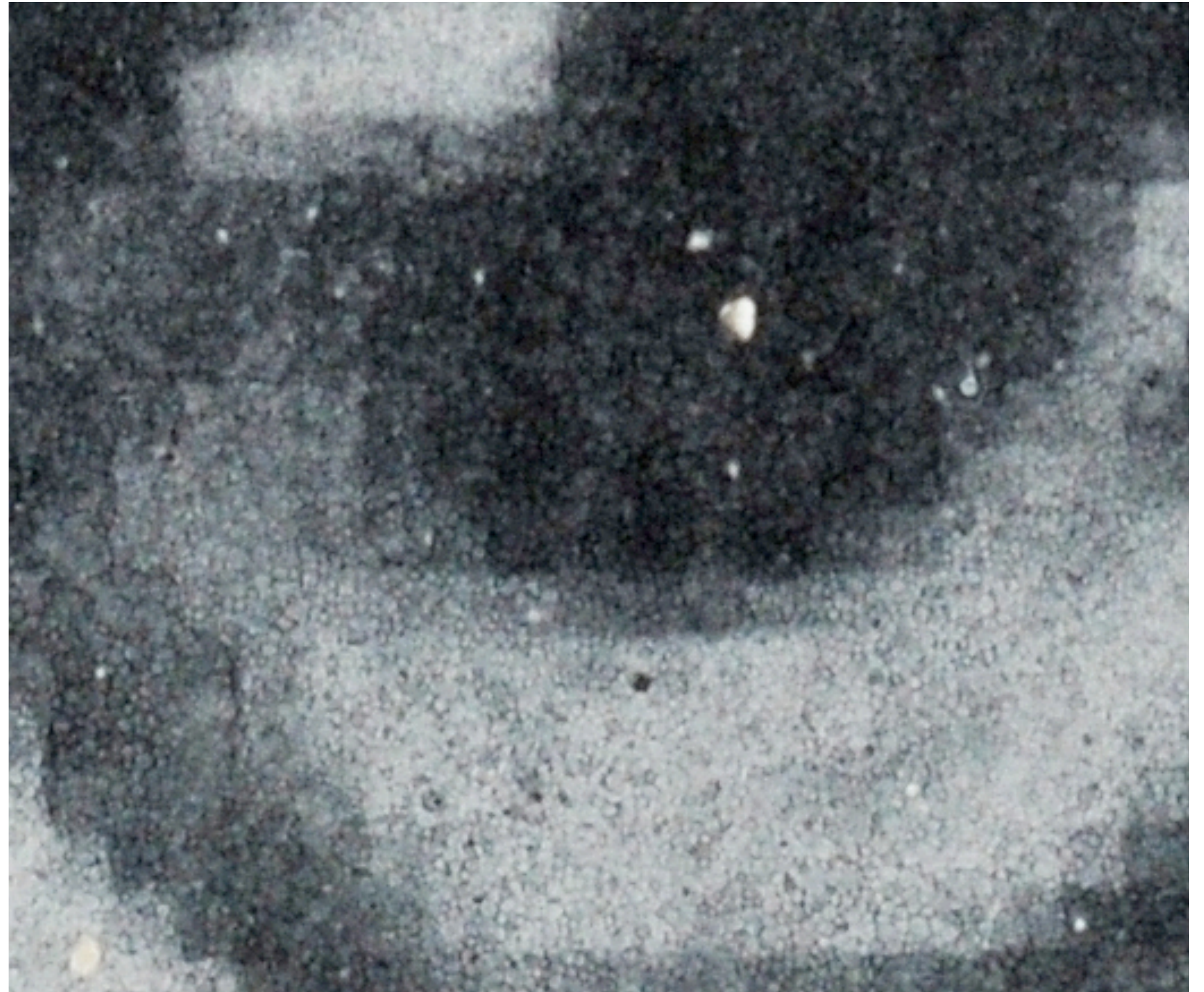


# E-ink provides a low-power display technology

Microencapsulated  
electrophoretic  
display



FREEscanRIP, CC BY 3.0, via Wikimedia Commons



By HorsePunchKid, CC BY-SA 3.0, via Wikimedia Commons



# Beyond the screen with: VR? AR? Projectors?

