

**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



# 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

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#### *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

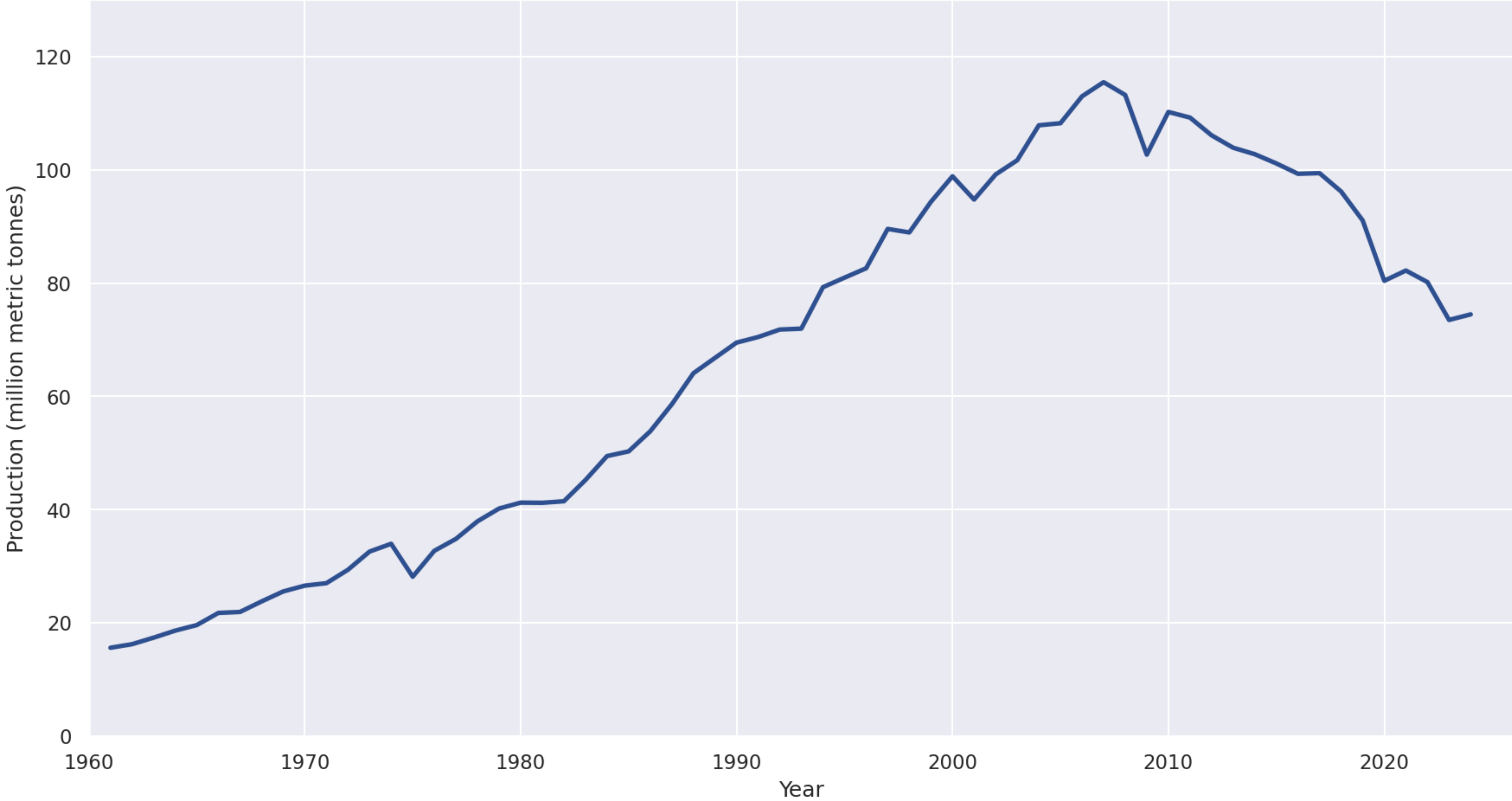
Quick links to related materials

Dynamically modifying or updating content

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# 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

The screenshot shows a document viewer interface with a toolbar on the left and a table of contents on the right. The main content area displays a bar chart titled 'Figure 3.3' and a text passage. A comment box is overlaid on the text.

**Figure 3.3**  
The activity profile for five administrative staff members.

Task	No Documents	Paper & Electronic	Electronic Only	Paper Only
Drafting Own Text	0	0	0	~100
Creating Own Data	0	~100	0	0
Editing Own Text	0	~100	0	0
Editing Own Data	0	0	~100	0
Rev. Another's Text	0	0	~100	0
Rev. Another's Data	0	0	~100	0
Collab. Authoring	0	0	~100	0
Collab. Data An.	0	0	~100	0
Conversations	0	0	~100	0
Meetings	0	0	~100	0
Reading Only	0	0	~100	0
Document Delivery	0	~400	0	0
Note Taking	0	0	~100	0
Formatting Text	0	~600	0	0
Form Filing	0	~400	0	0
Typing Text	0	~2400	0	0
Organizing Docs.	0	~800	~100	0
Photocopying	0	~700	0	0
Dealing with Mail	0	~400	0	0
Printing	0	~100	0	0
Searching for Docs.	0	~100	0	0
Searching for Info.	0	0	~100	0
Dealing w. Software	0	0	~100	0
Telephone Activity	0	0	~300	0
Thinking & Planning	0	0	~100	0
Responding to Mail	0	0	~200	0
Language Class	0	0	~200	0

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

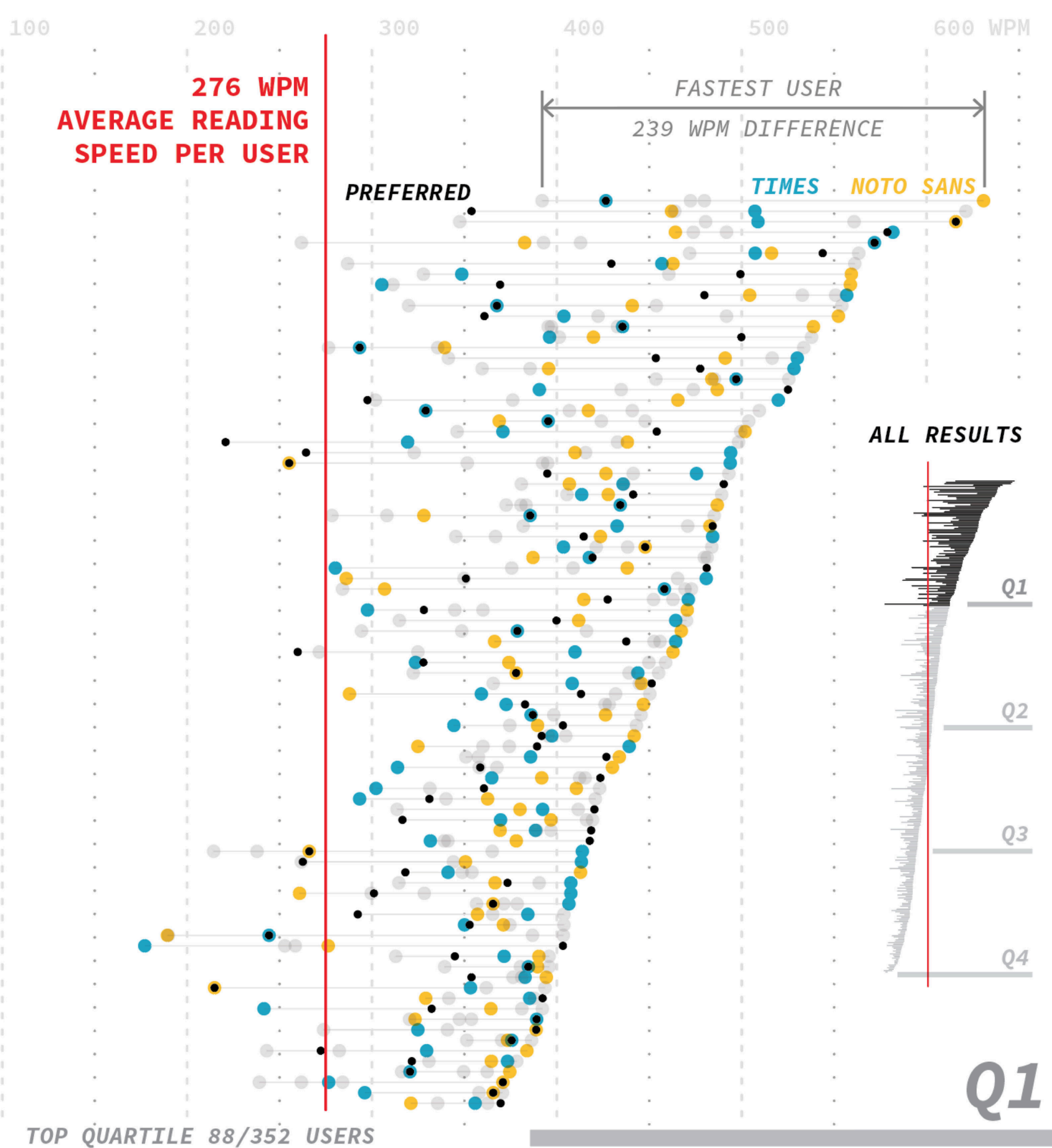
# 1. Typography

# 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



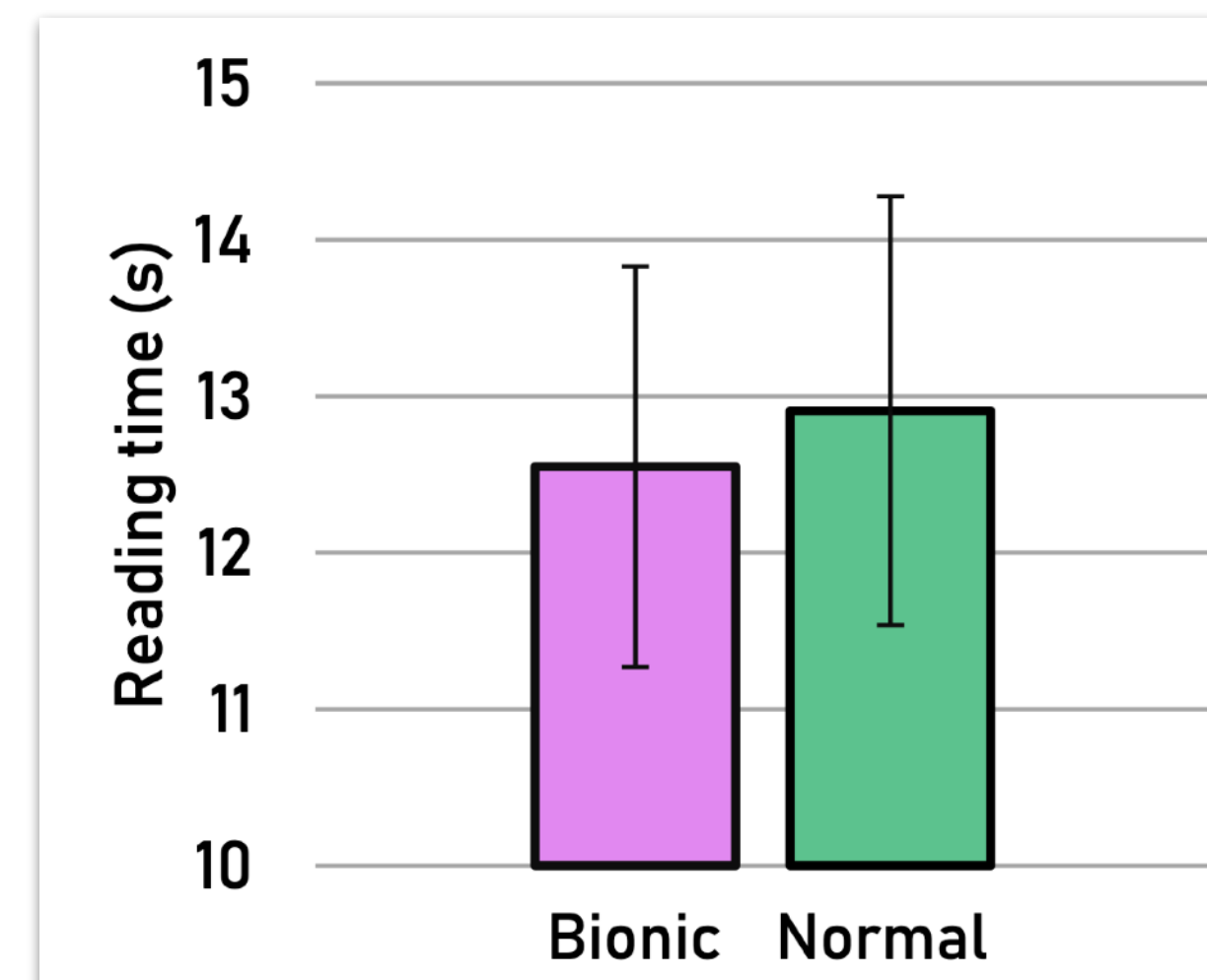
# “Bionic reading” doesn’t seem to make a difference

**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).<sup>10</sup> 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

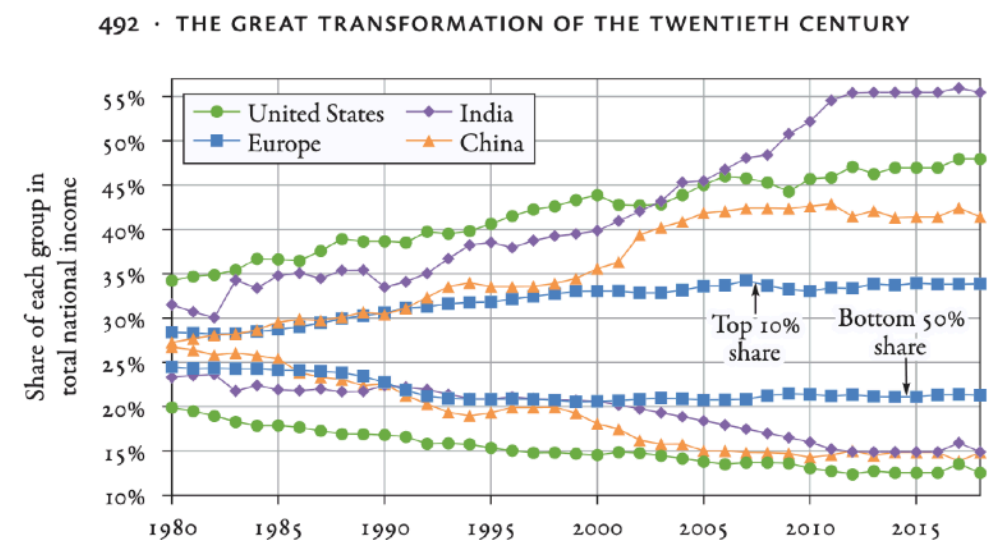


FIG. 11.1. Divergence of top and bottom incomes, 1980–2018

*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.<sup>11</sup> 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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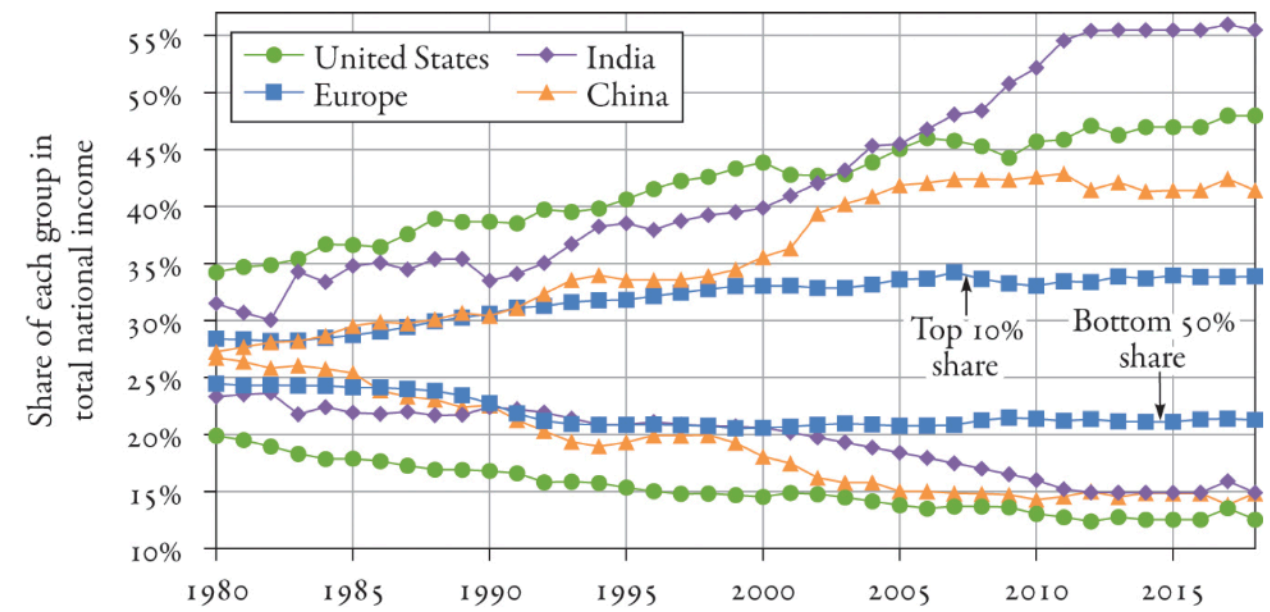


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bottom half of the US population today (and that the gap between the United States and Europe is due to the gap prior to taxes and transfers).

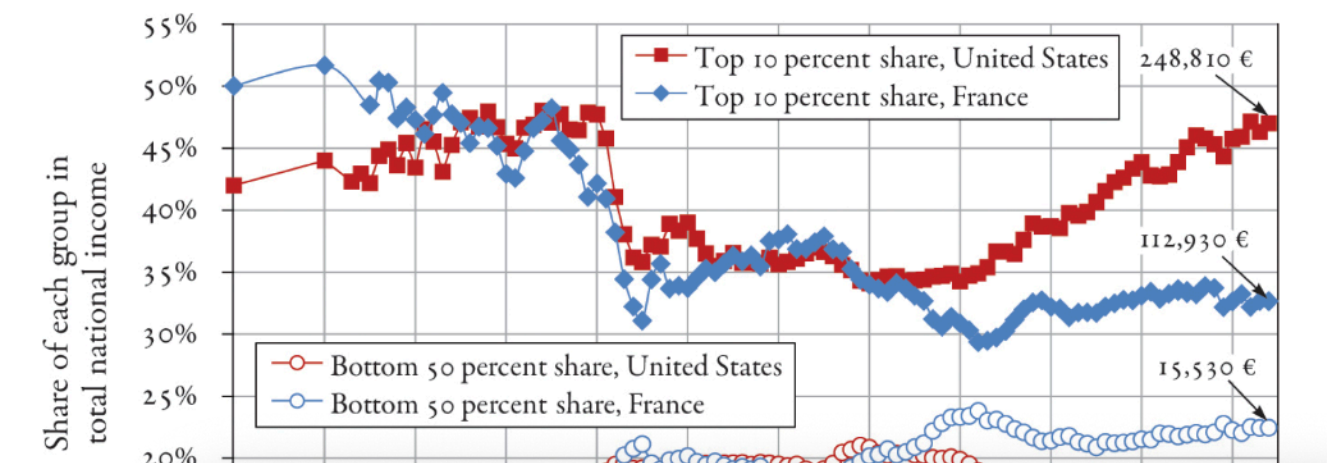


FIG. 11.2. Bottom

*Interpretation:* In France (and Europe) still received a purchasing power

For all these reasons, the limits of the labor law), the emergency could really conceive the experience rates on productivity or design. Our first private ownership is a regional, sta

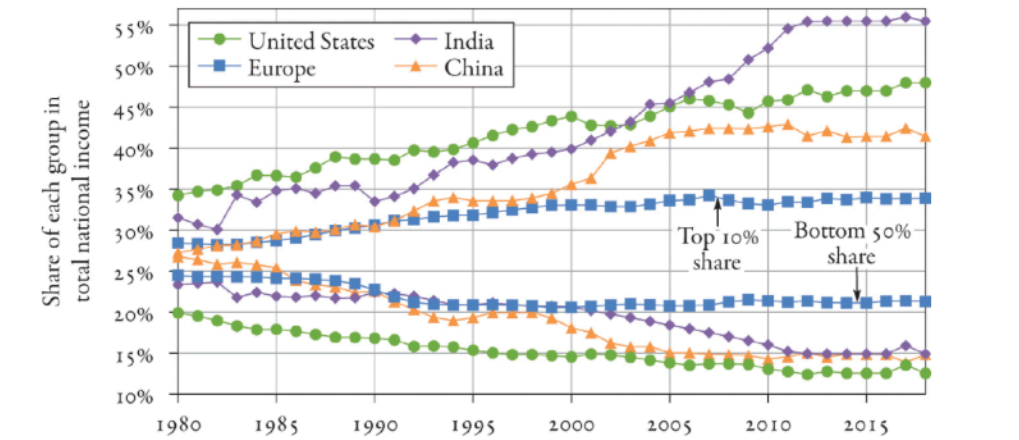


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# Layout quality depends on the reading system

## Fixed layout on laptop

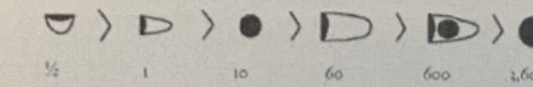
Dating to c. 3300 BC from Uruk on the lower Euphrates between Babylon and the Persian Gulf, the earliest of all clay tablets is only one step up from the *bullae* system, still comprising a system of numerals and (perhaps standardized, stylized) pictograms identifying commodities (illus. 11). In one 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

tablets – co-existed for many centuries. The message of both was always: ‘so and so many of such and such a commodity’. More was not demanded of this system.



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.

Though this is still not complete writing, as it fails to use marks that relate conventionally to articulate speech, it is nevertheless the successful conveyance of complex ideas through graphic art (illus. 13). It displays more sophisticated accounting

# **3. Interaction**

# Context on-demand for terms, references, cites

WIKIPE...  
The Free Encycl...

Mitoch...

Article Talk

From Wikipedia, the...

"Mitochondria" r...  
the Canadian ba...

A mitochondrion (/...  
pl.: mitochondria) is...  
cells of most eukary...  
plants and fungi. Mit...  
membrane structure...

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...

to generate adenosine triphosphate (ATP), which is used throughout the cell as a source of...

[https://en.wikipedia.org/wiki/Adenosine\\_triphosphate](https://en.wikipedia.org/wiki/Adenosine_triphosphate)

"Mitochondrion." Wikipedia 2023

i.e. token  $t$  and frame  $f$ ) are given

embeddings

$$s_{ft} = (s_f^{pred})^T U s_t^{role}$$

unary scores frame bilinear transformation token

n be computed in parallel across  
ames in an entire minibatch. We ca

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

$\stackrel{(1)}{=} 2\mathbf{u} \times \mathbf{v}.$

Since we simply changed order of the terms in the vector product, we could have simply used the result from [Equation \(4.9\)](#), and rule

**Equation 4.9:**

$$(\mathbf{u} + \mathbf{v}) \times (\mathbf{u} - \mathbf{v}) \stackrel{(2,4)}{=} (\mathbf{u} + \mathbf{v}) \times \mathbf{u} - (\mathbf{u} + \mathbf{v}) \times \mathbf{v}$$

$$\stackrel{(3)}{=} \underbrace{\mathbf{u} \times \mathbf{u}}_{=0} + \mathbf{v} \times \mathbf{u} - \mathbf{u} \times \mathbf{v} - \underbrace{\mathbf{v} \times \mathbf{v}}_{=0}$$

$$\stackrel{(1)}{=} -2\mathbf{u} \times \mathbf{v}.$$

$\mathbf{v}$

Ström et al. "Immersive Linear Algebra." 2020

system [20]: a recurrent neural network (RNN) tra...  
text tran...

Let a...  
{(x^{(1)}, ...  
time-slic...  
normaliz...  
bin in th...  
final tra...  
chosen t...

**Deep Speech: Scaling up end-to-end speech recognition**

Awni Y. Hannun Carl Case +8 authors A. Ng

arXiv.org · 17 December 2014

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](#)

(i)  
, x^{(i)}  
= 0,  
tem,  
he R...  
nce,

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

Price

[+ 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

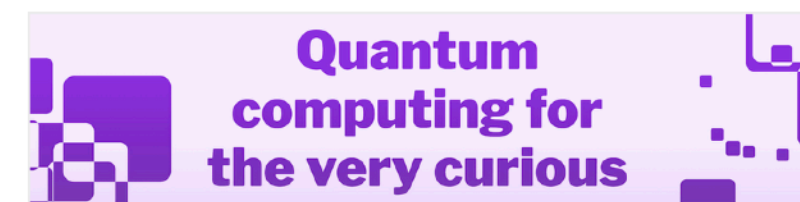
server.rb checkout.html success.html cancel.html [Download](#)

```
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_51SxEnrLaiuIBIIhfeCHdoHZFZJq70qsVhSrrmqsdNLW6d7i8Agqg1V963aBj5DCXrNDojhqau'
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>

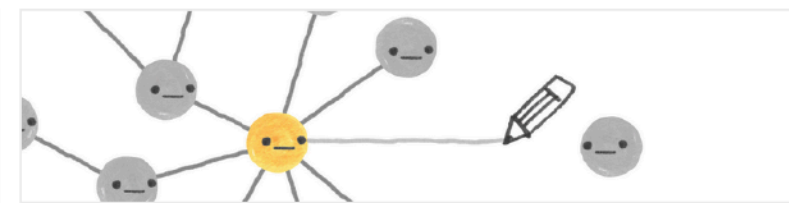
# “Explorable explanations” leverage interaction and simulation to explain concepts

via <https://explorables>



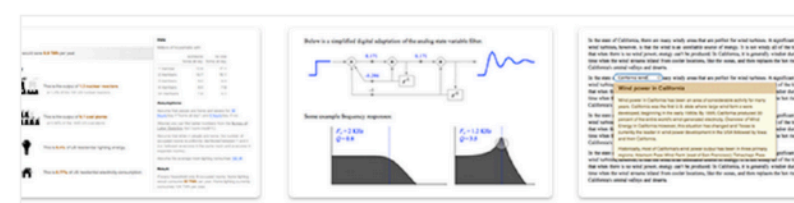
## ★ Quantum Computing for the Very Curious

physics programming  
an introduction with embedded Spaced Repetition



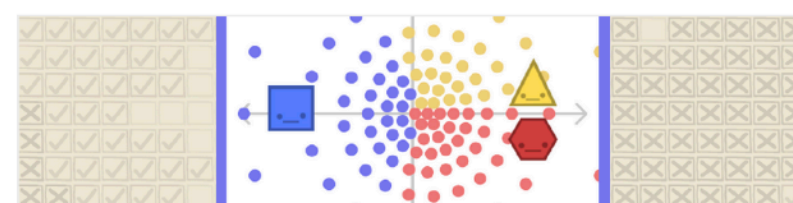
## ★ The Wisdom and/or Madness of Crowds

social science  
an interactive guide to human networks



## ★ Explorable Explanations

further reading  
the 2011 essay that coined the phrase 'Explorable Explanation'



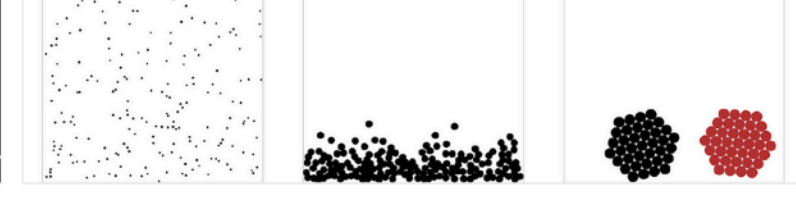
## ★ To Build A Better Ballot

civics  
an interactive guide to alternative voting systems



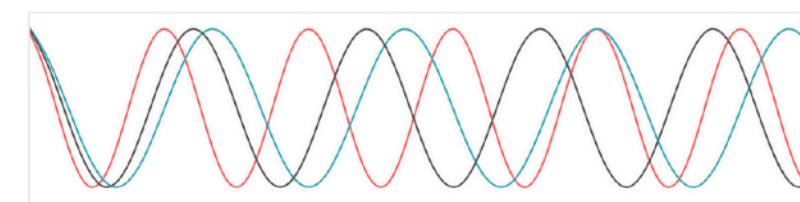
## ★ What Happens Next?

biology  
covid-19 futures explained, with playable simulations



## ★ Many Tiny Things

physics  
a playful guide to statistical physics



## ★ LightNote.co

art  
a playful introduction to music theory



## ★ An Interactive Introduction to Fourier Transforms

math



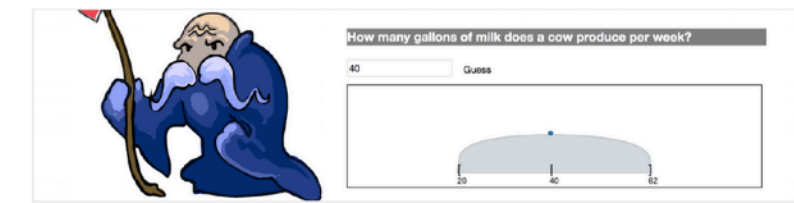
## ★ Gears

math physics  
a very, very deep dive into gears



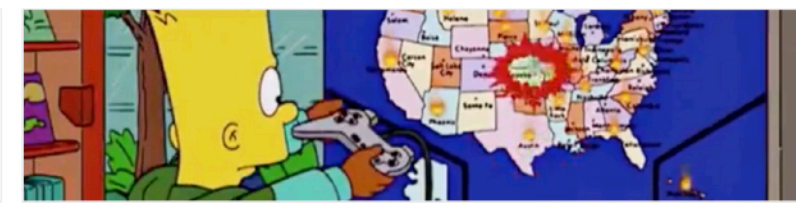
## ★ A Slower Speed of Light

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



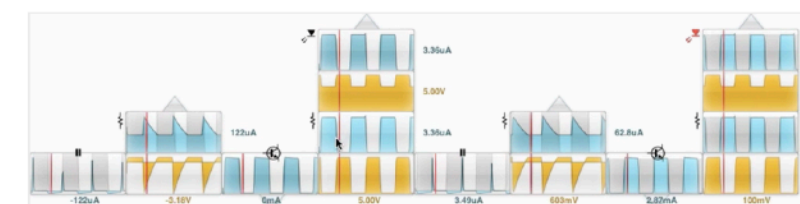
## ★ Adventures in Cognitive Biases

psychology  
a game to reduce overconfidence bias & train Bayesian thinking



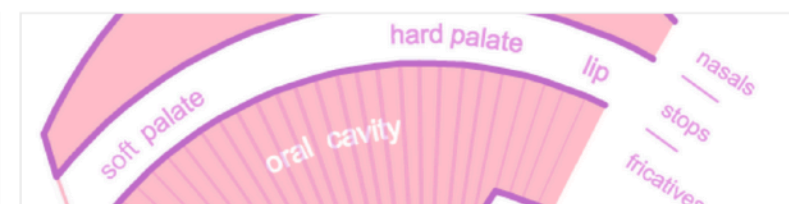
## ★ The 2018 Explorables Jam

misc  
a hackathon to explain an idea through play!



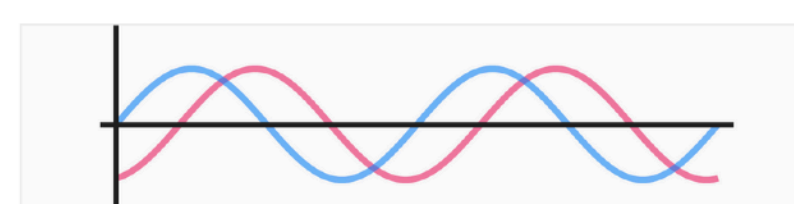
## ★ Media For Thinking The Unthinkable

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



## ★ Pink Trombone

misc  
a horrifying toy that shows how the human voice works



## ★ Let's Learn About Waveforms

math physics  
an interactive guide to waves & harmonics



## ★ Virus: The Beauty of the Beast

biology  
an interactive documentary on the mathematical majesty of viruses



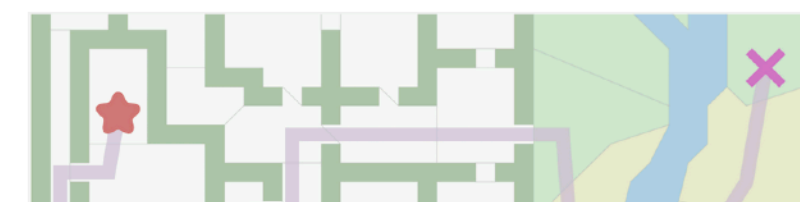
## ★ Back to the Future of Handwriting Recognition

programming  
an interactive history of handwriting recognition software



## ★ Trigonometry for Games (Making a Homing Rocket)

art math programming  
an interactive gamedev tutorial



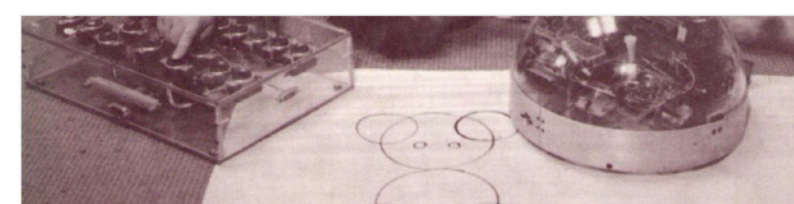
## ★ Introduction to A\*

programming  
how to program pathfinding for your game



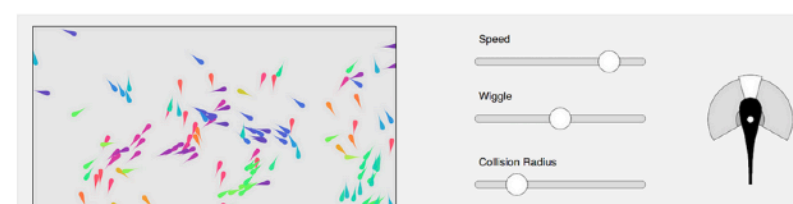
## ★ Fireflies

biology  
a small, serene simulation of self-synchronization



## ★ Mindstorms

further reading  
the classic 1980 book on how children learn, through play



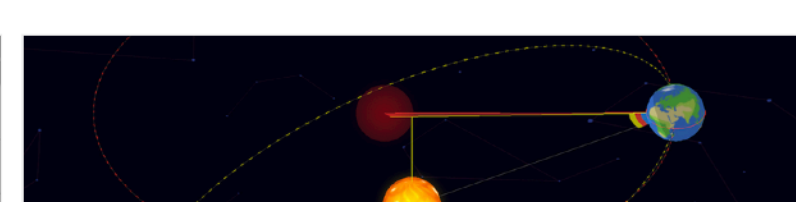
## ★ Complexity Explorables

biology math physics  
explorations of complex systems



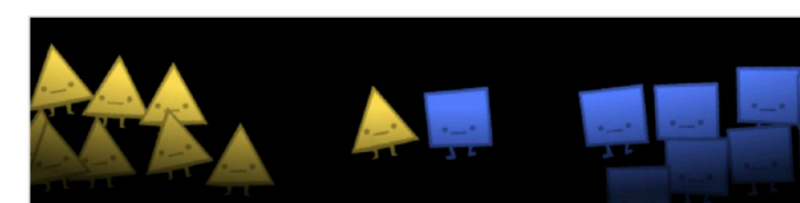
## ★ Learning Music

art  
an interactive tour to making music



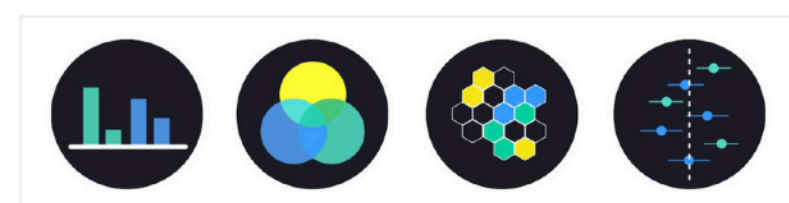
## ★ What Is A Day?

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



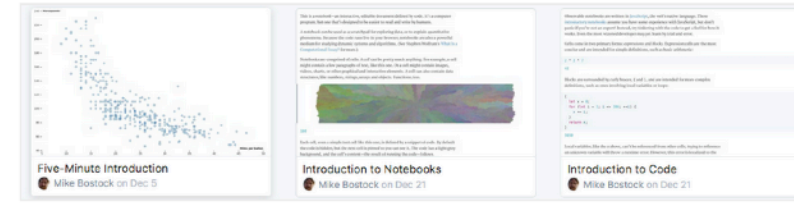
## ★ Parable of the Polygons

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



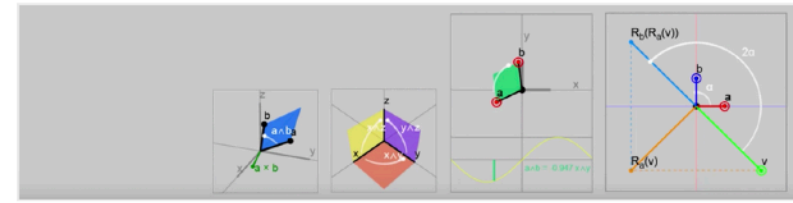
## ★ Seeing Theory

math  
a visual introduction to probability and stats



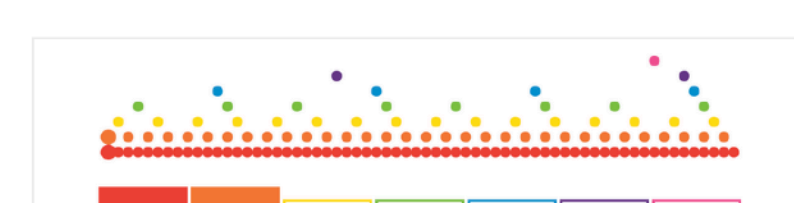
## ★ Observable

tools  
a better way to code, discover, and communicate



## ★ Let's Remove Quaternions From Every 3D Engine

math programming  
an introduction to Geometric Algebra



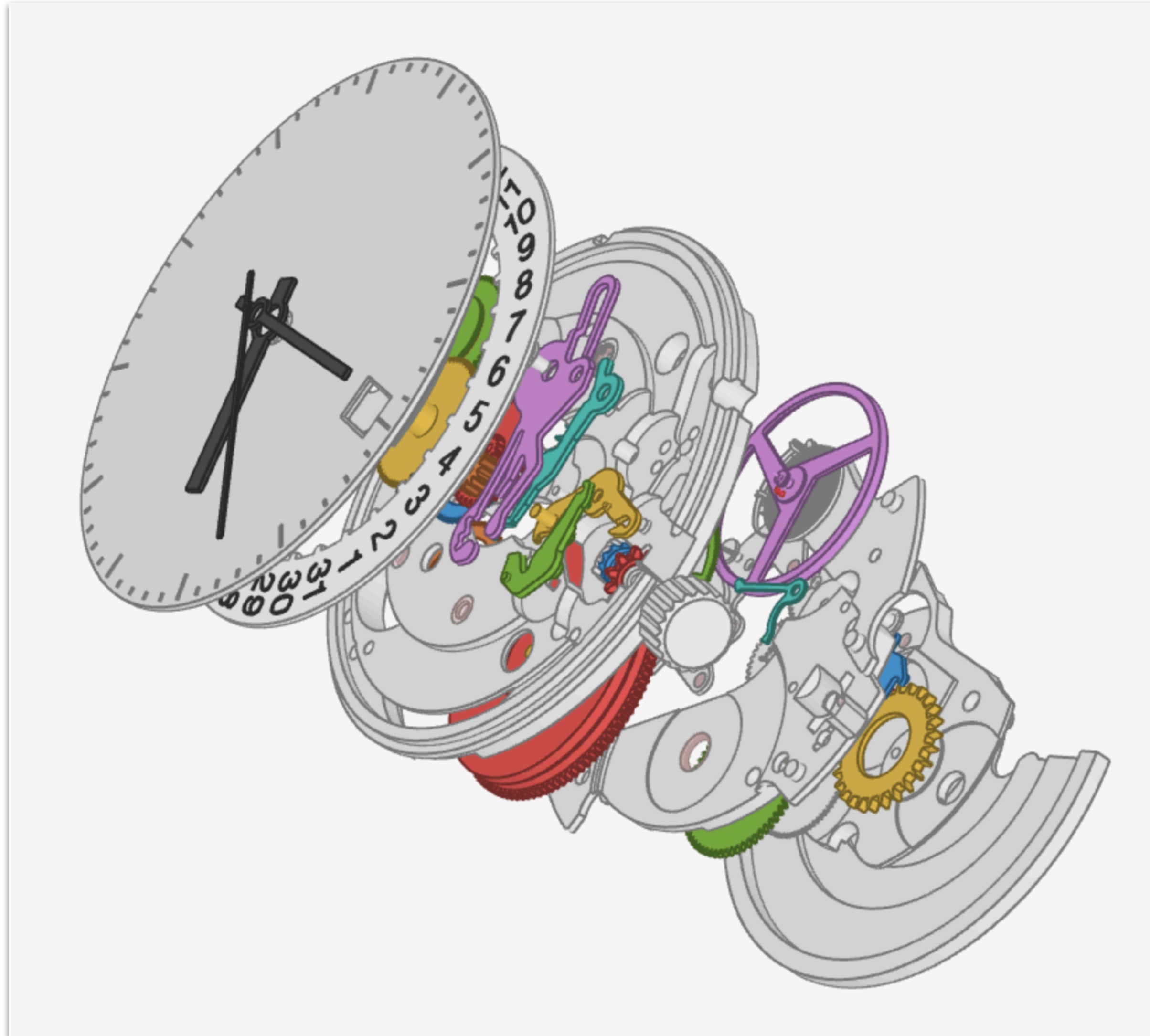
## ★ How To Remember Anything Forever-ish

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.

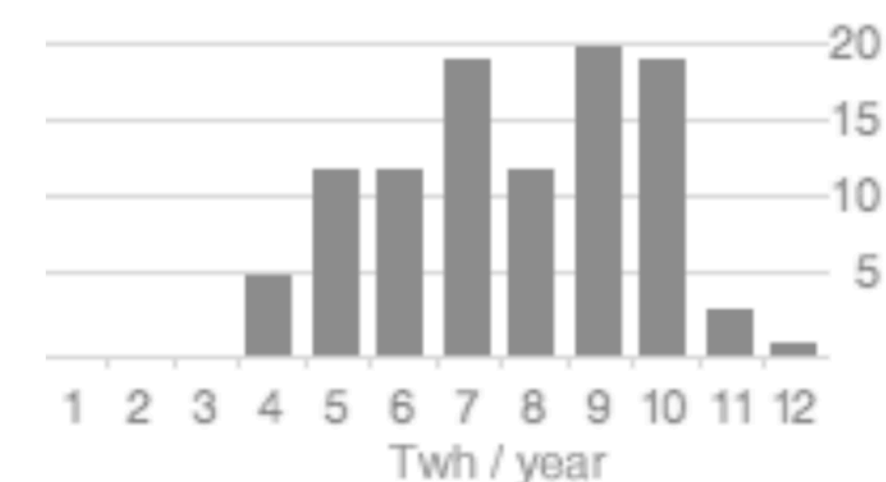


This is **0.91%** of US residential electricity consumption.

### 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**

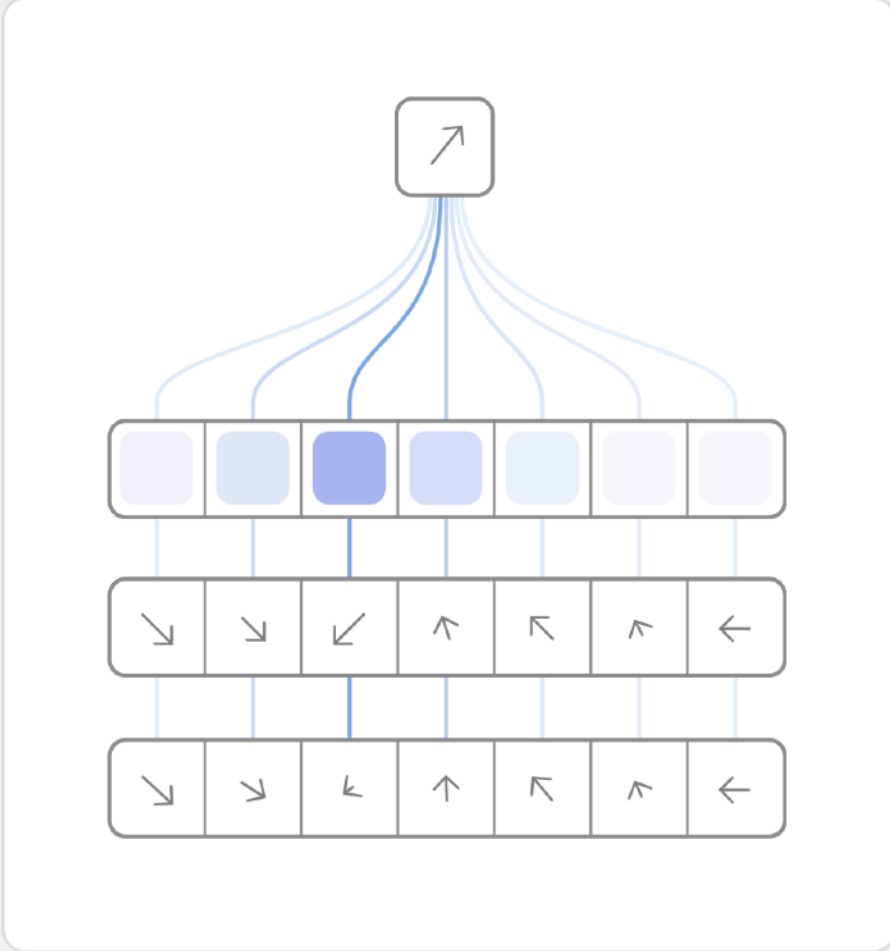
This is \$1.56 per year per person.


### Waste

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

<https://worrydream.com/TenBrighterIdeas/>

# 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

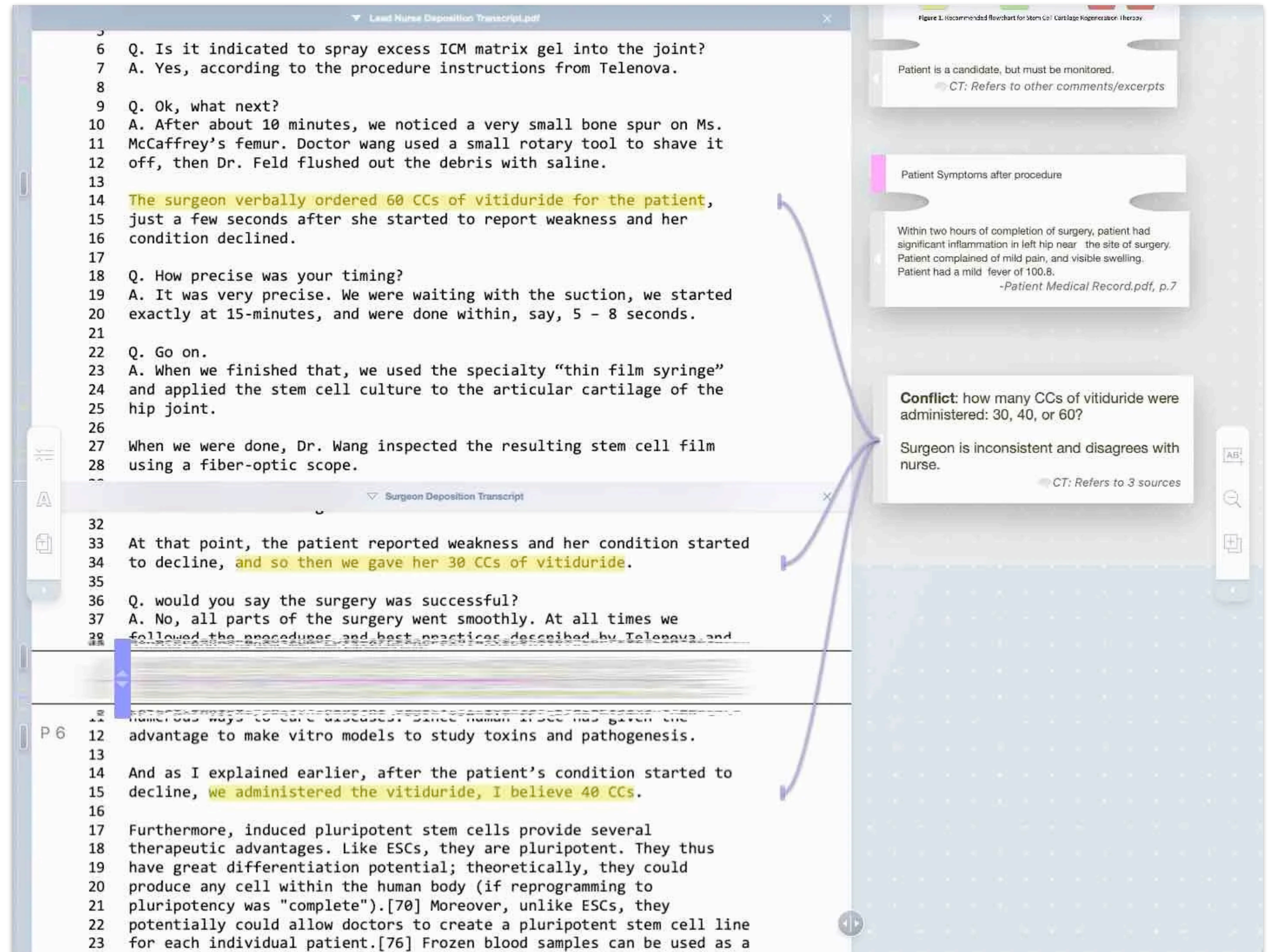


Noteful

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

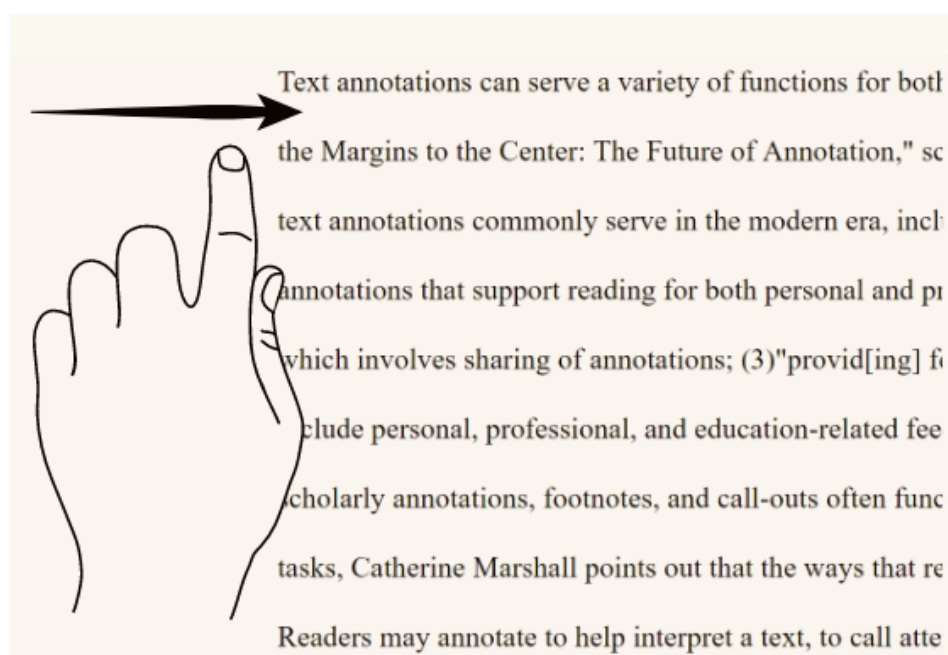
# LiquidText provides a canvas for infinite margins

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

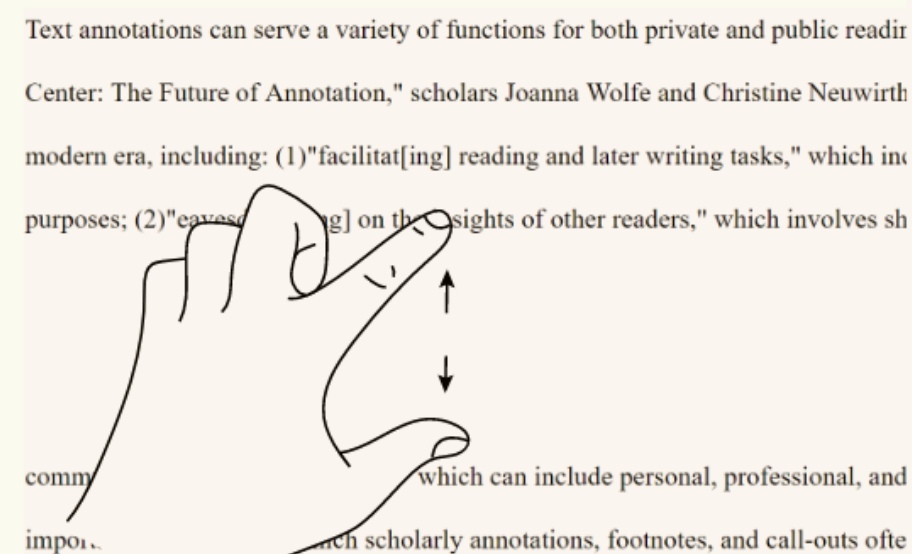


# Making space for notes on text

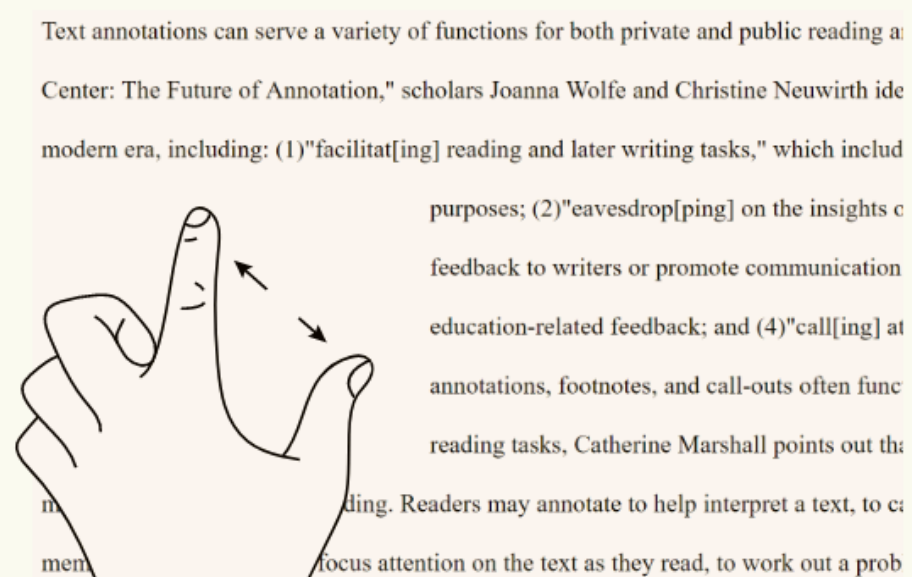
## TOUCH-BASED



side of paragraph

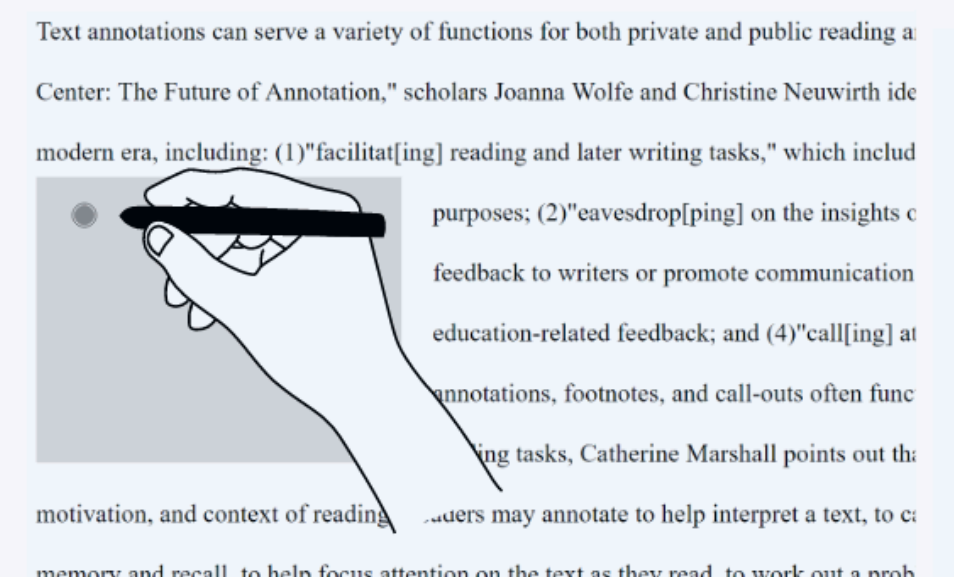
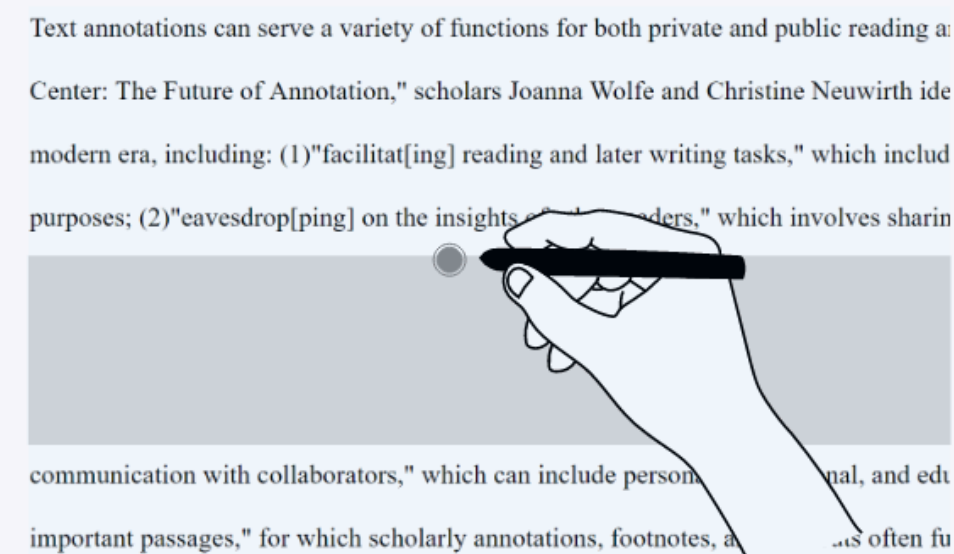
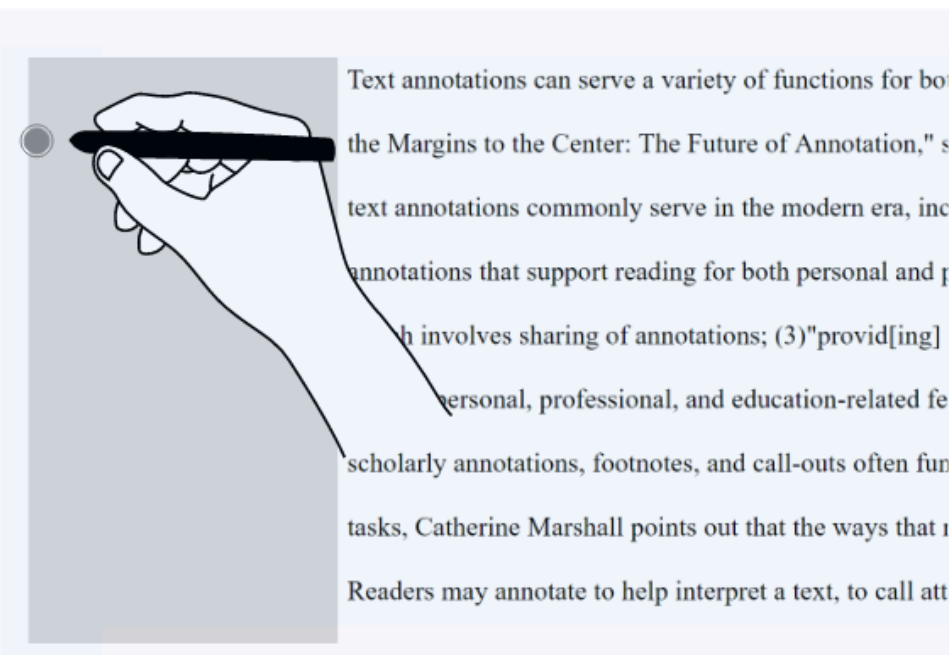


between lines



wrapped in paragraph

## PEN-BASED



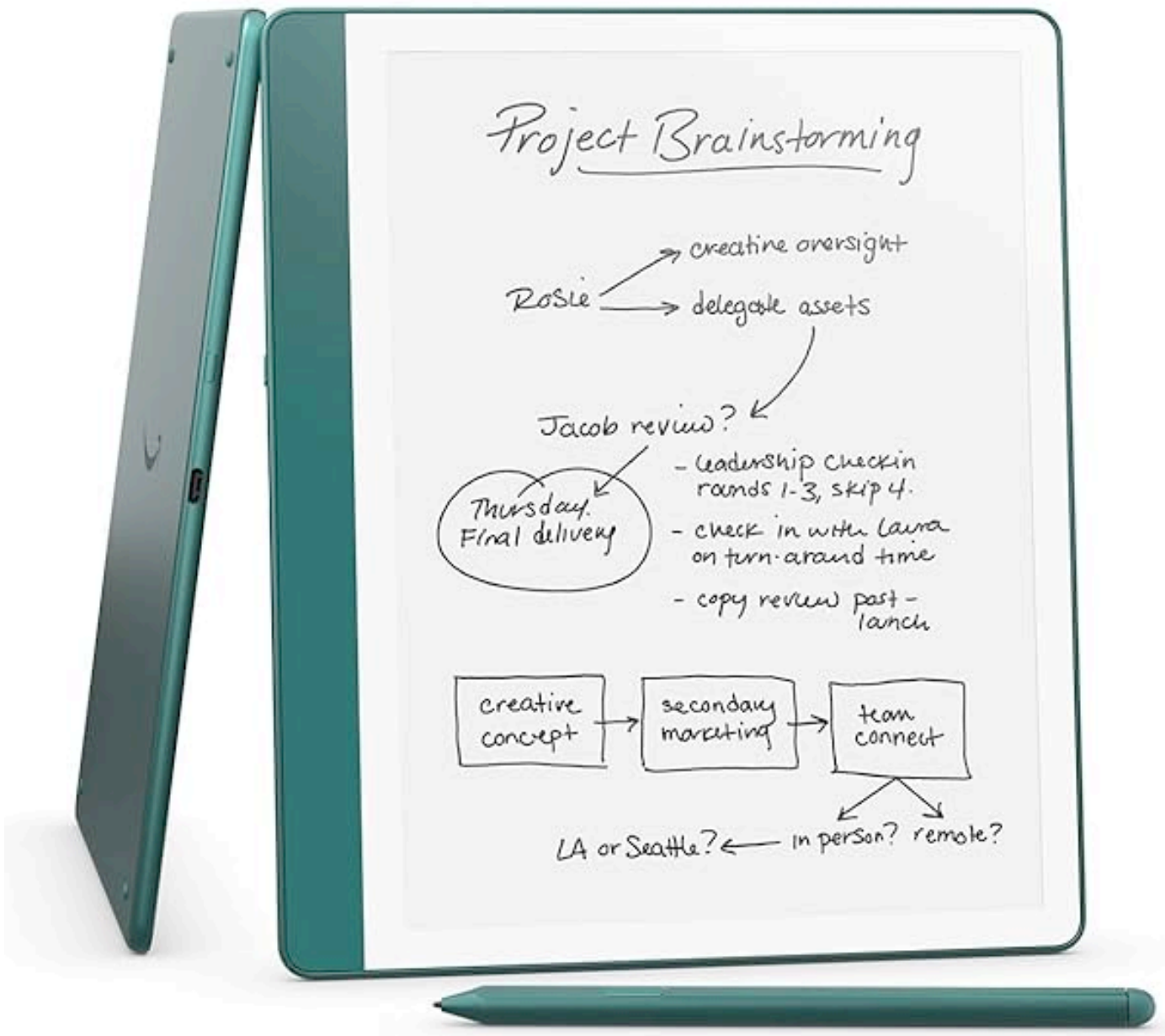
- Key ideas: where annotations are added, when does the user indicate which space to use

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

- Adopted by Kindle Scribe

# 5. Hardware

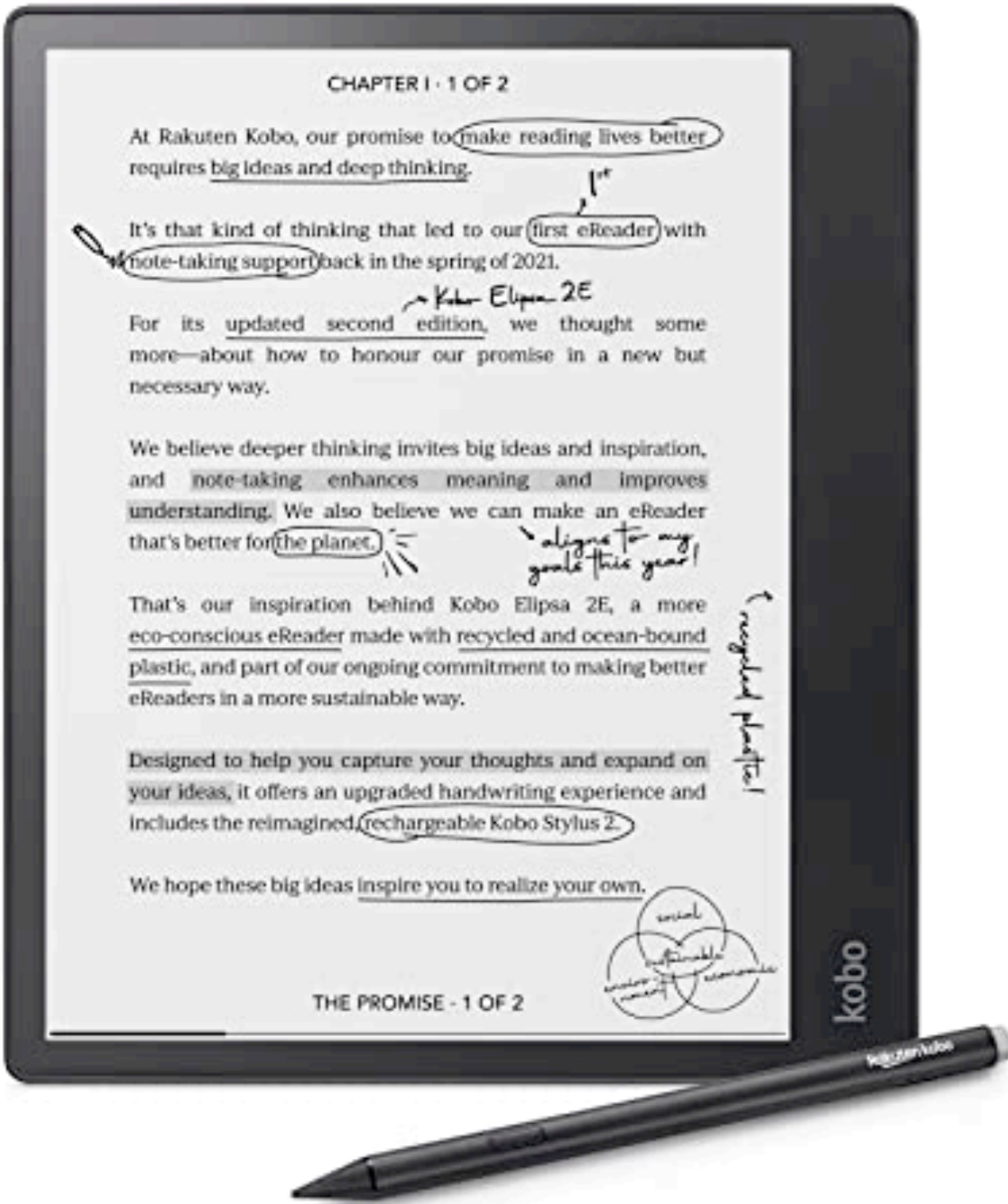
# E-paper tablets became popular in the last decade



Kindle Scribe



reMarkable



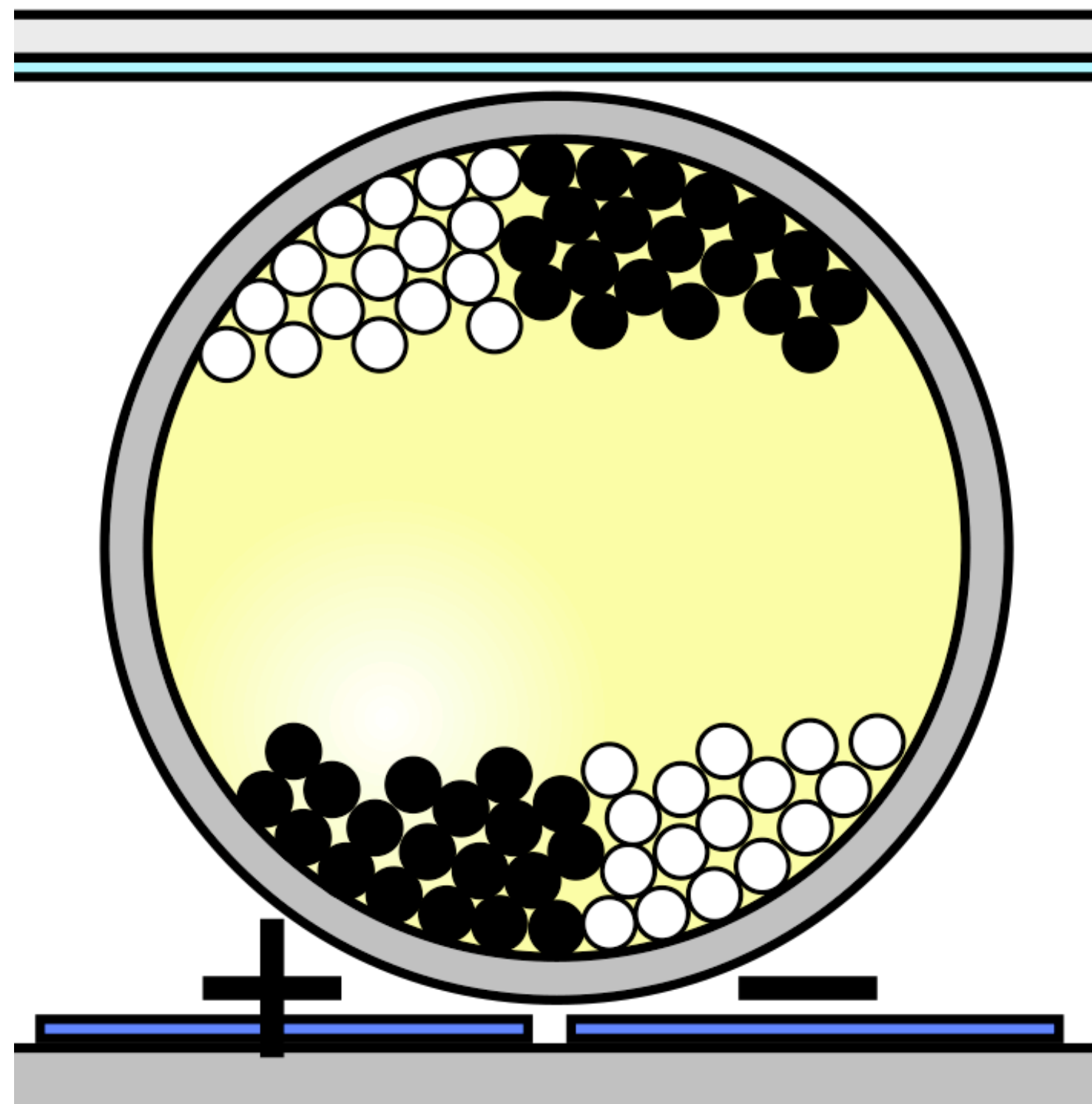
Kobo Elipsa



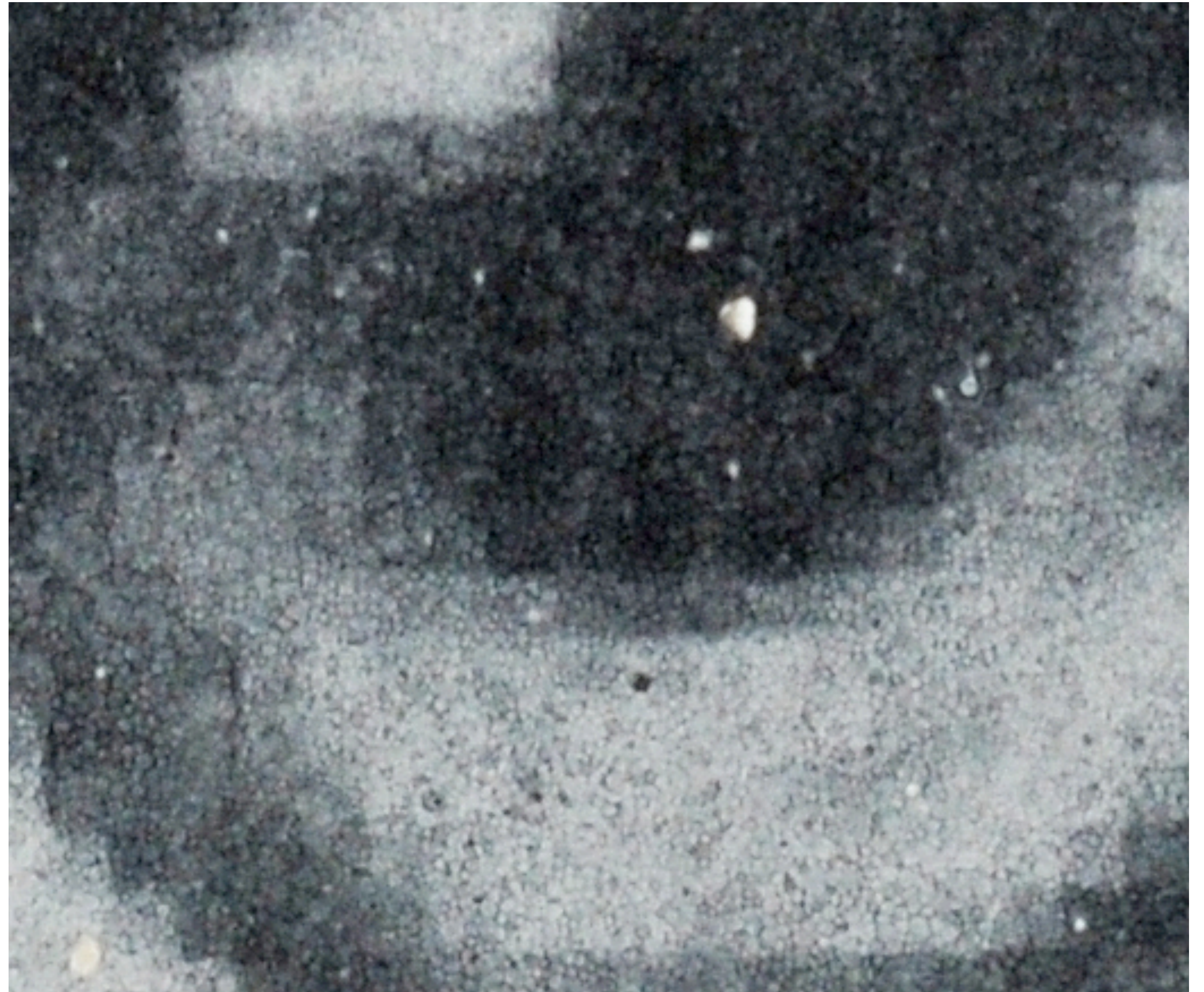
Daylight

# 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?

