1

Remember, Doctor…

Memory,
Medical Education,
and
A Meander Down the Rabbit Hole of Cognition

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Michael Downey, MD
Part I, MHI Grand Rounds 12.15.2025

2

Disclosures:

- No finical disclosures relevant to this talk
- No off-label medication or device utilization will be discussed
- Any cardiovascular topics discussed are tangential to the main cognitive takeaway of this presentation
  (Yes, this is a bit a of a swing on our part)

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CME Goals for this talk:

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PREAMBLE

Thinking about Thinking

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Knowledge is POWER (…?)

- "I know that I know nothing."
- "I am wiser than this [human], for neither of us appears to know anything great and good; but [they] fancy [they] know something, although [they know nothing]; whereas I, as I do not know anything, so I do not fancy I do. In this trifling particular, then, I appear to be superior to [them], because I do not fancy I know what I do not know."
  - *Socrates* via Plato's Apology

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Knowledge is … Knowledge

- "As our circle of knowledge grows, so does the circumference of darkness surrounding it."
  - *Albert Einstein*
- "I was born not knowing and have only had a little time to change that here and there."
  - *Richard Feynman*

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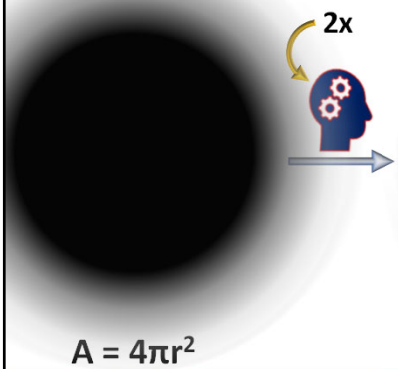
"As our circle of knowledge grows, so does the circumference of darkness surrounding it."

-Albert Einstein



$A = 4\pi r^2$

$A' = 4\pi(2r)^2 = 16\pi r^2$

$\frac{16\pi r^2}{4\pi r^2} = 400\%$ **more unknown**

Have we lost knowledge?

Or can we now recognize, our next step into the unknown?

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AMBLE

Medical Education and Memory

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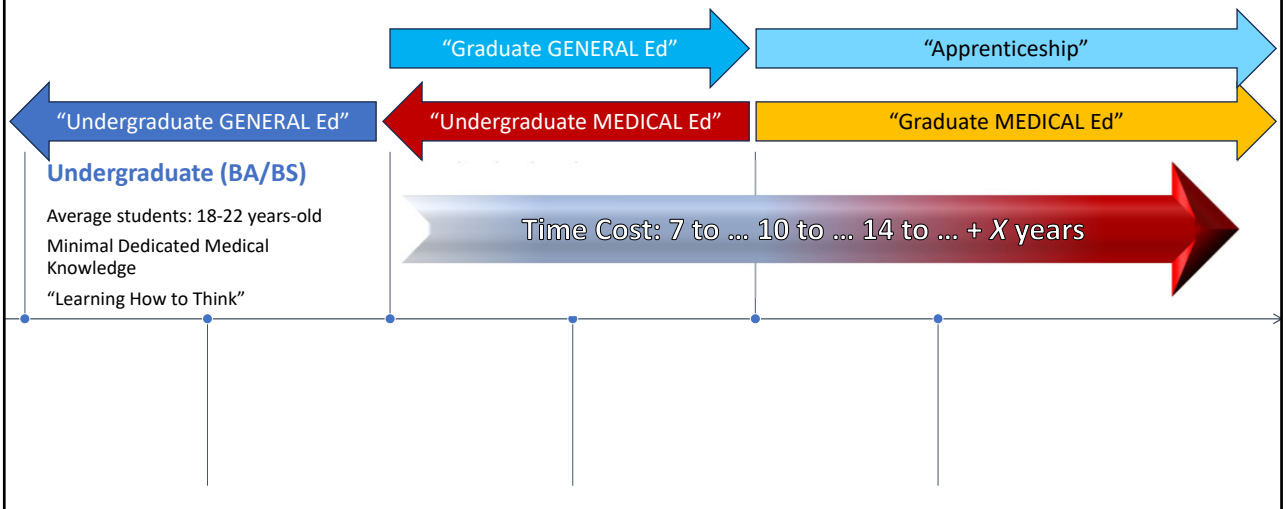
Medical Education Pathway in Wide Strokes



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Why talk about Undergraduate Med Ed (UME)?

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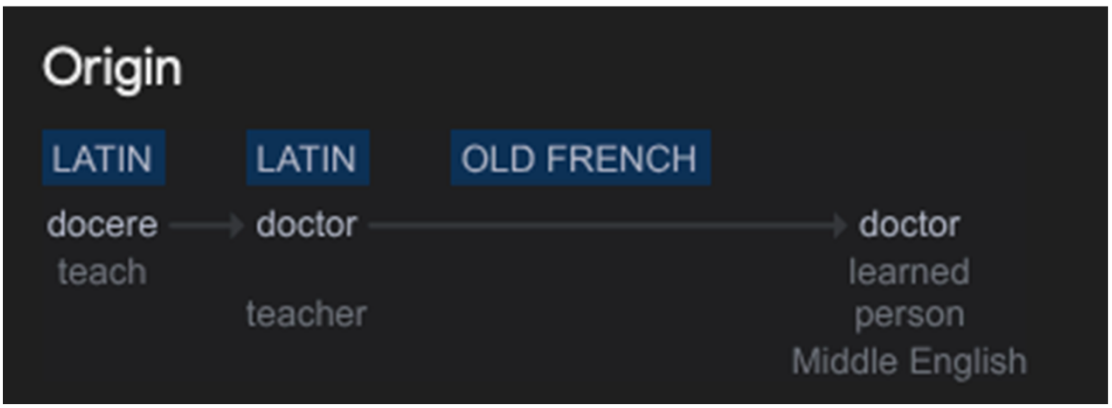
Why talk about Undergraduate Med Ed (UME)?



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Current State of Undergraduate Medical Education

Transition to competency focused learning models

Theoretically…

- Reduced inter-student competition
- Increased efficiency of training - while ensuring competence
- Expedite pipeline to fill national physician deficit

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National and Local Shifts in UME

National Changes (USMLE)

STEP 1 transitioned to PASS/FAIL in 2022

- Assuming shortest timeline to matriculation…
- Trainees under this model will enter general cardiovascular disease* fellowship on July 1st, 2027

Local (but diffuse) Changes (Medical Schools)

Almost all (US based) medical schools transitioned to Pass/Fail

Class rank is largely unknown

Remote learning predominates

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So what have the data show (if anything)?

- Remember … July 1st, 2027

Step 1 Passing Rates	2017	2018	2019	2020	2021	2022	2023	2024
Total Step 1 Exams	42,420	42,190	43,048	38,734	47,653	53,929	56,200	57,324
Overall Step 1 Pass Rate	86%	87%	89%	92%	88%	82%	79%	80%
Total Step 1 Fails	6,119	5,357	4,614	3,104	5,894	9,939	11,569	11,515

Percentile with Fail Line

Pass / Fail Format

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https://www.usmle.org/performance-data

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System in Flux

Back to Basics

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Why talk about memory now?

- (Distorted) Digital Mirror
- Rate of technological change > human biologic evolution
- Multiple changes to medical education with long lag time
- Self utilization for optimization
- Strategic topic selection

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Why talk about memory now?

- **(Distorted) Digital Mirror**
  - Human memory ≉ Digital memory
  - Analogies are useful
  - Overextrapolation isn't

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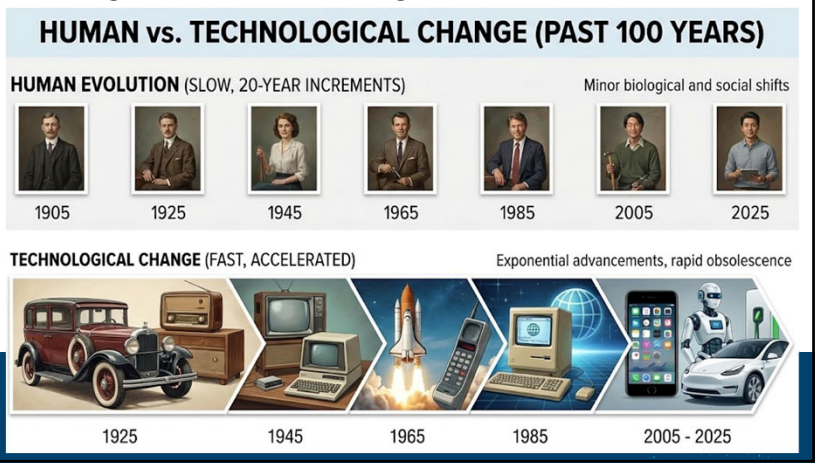
Why talk about memory now?

- (Distorted) Digital Mirror
- **Rate of technological change > human biologic evolution**



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Why talk about memory now?

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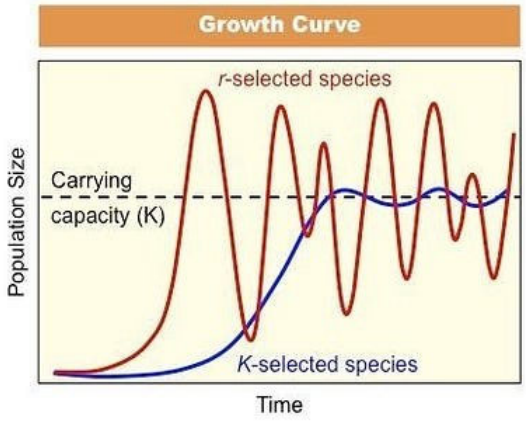
- **Rate of technological change > human biologic evolution**

$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$$



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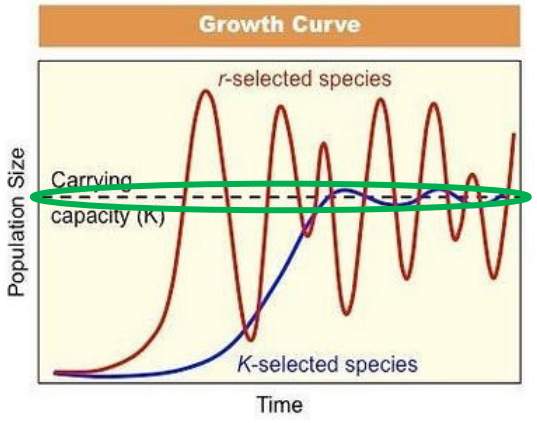
Why talk about memory now?

- (Distorted) Digital Mirror
- **Rate of technological change > human biologic evolution**

$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$$

If K for humans has been expanded due to different energy sources to generate kcal … will K drop as digital power demand grows?

E = E



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Why talk about memory now?

- (Distorted) Digital Mirror
- Rate of technological change > human biologic evolution
- **Multiple changes to medical education with long lag time**

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https://www.usmle.org/performance-data

23

Why talk about memory now?

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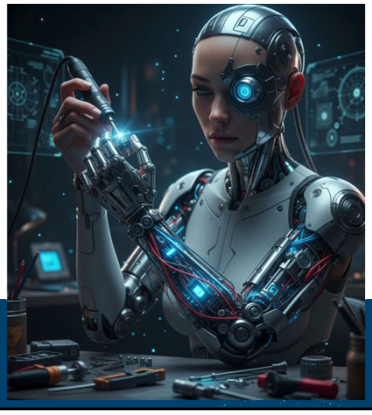
- **Self utilization for optimization**
- **Strategic topic selection**



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Memory is … Total Recall?

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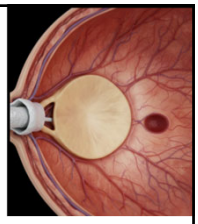
Making a Memory



- **Initial Attention and Encoding**
- **Attention is Selective:** We filter out most sensory stimuli; only selected information proceeds to memory formation.
- **The Thalamus** acts as a relay center for sensory input, and the **Hippocampus** assesses information for long-term storage.
- **Encoding Types (Depth of Processing):** The **deeper** the processing, the stronger the memory trace.
  - **Shallow:** Visual (e.g., appearance) or Acoustic (e.g., sound).
  - **Deep (Semantic):** Thinking about the **meaning** of the information and relating it to existing knowledge.

(Craik & Tulving, 1975)

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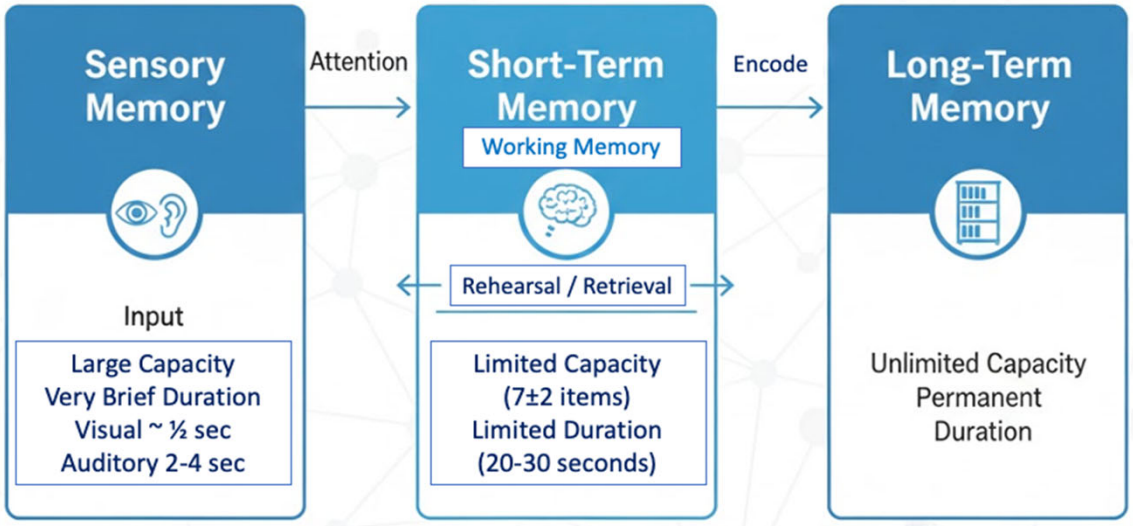
Atkinson-Shiffrin Three-stage Model of Memory



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Factors Enhancing Coding into LTM …

Loading pending Dr. Evers

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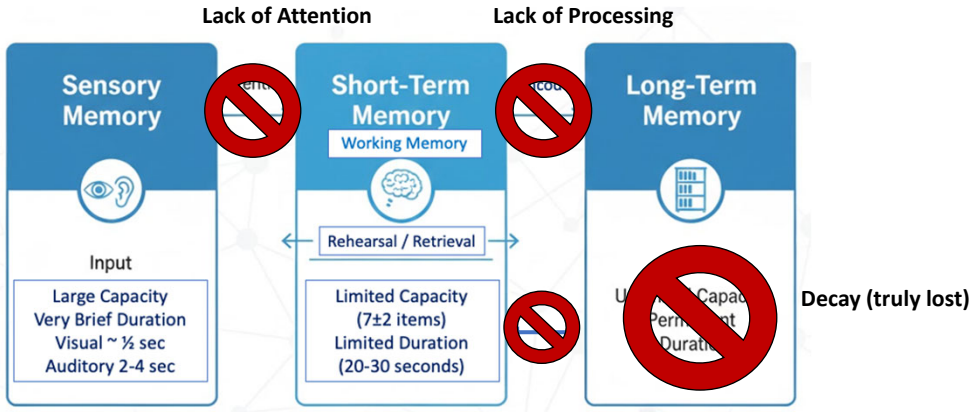
Factors Detracting From Memory Retention



Que lack

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Context-dependent memory in two natural environments: On land and underwater. *British Journal of Psychology, 66*(3), 325-332

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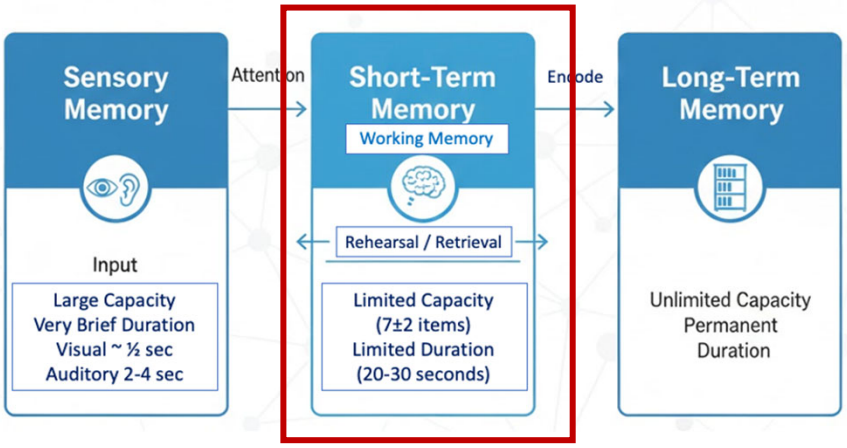
Retrieval and Modification Process of Memory



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Fear memories require protein synthesis in the amygdala for reconsolidation after retrieval. *Nature, 406*(6797), 722-726.

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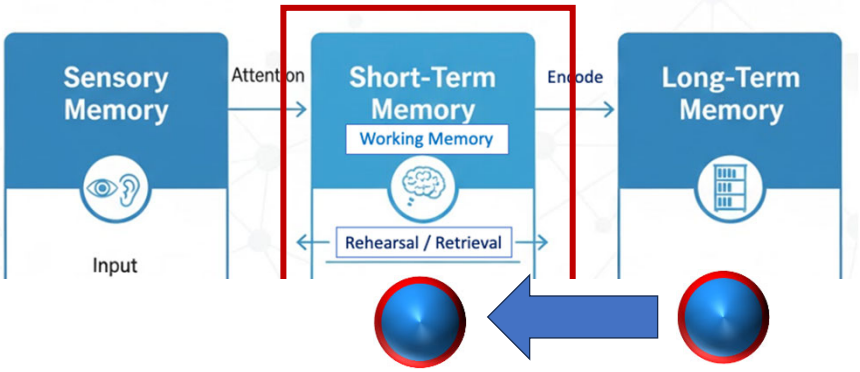
Retrieval and Modification Process of Memory



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Fear memories require protein synthesis in the amygdala for reconsolidation after retrieval. *Nature, 406*(6797), 722-726.

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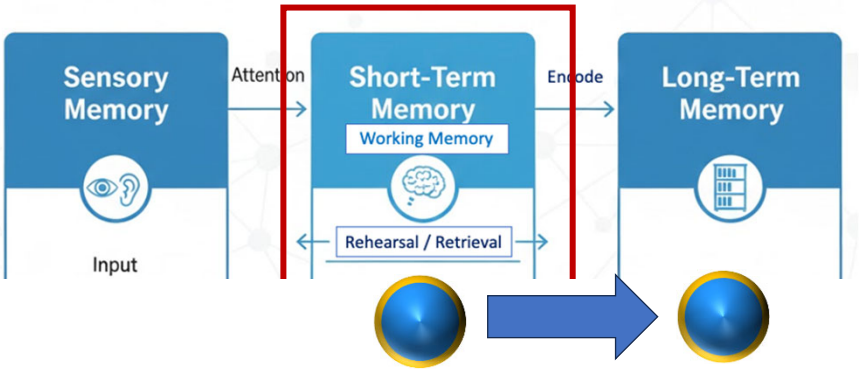
Retrieval and Modification Process of Memory



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Fear memories require protein synthesis in the amygdala for reconsolidation after retrieval. *Nature, 406*(6797), 722-726.

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So, after that long and winding road…

Change isn't coming to MedEd…

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CME Goals for this talk:

Goals:

1.) Revisit idea of 'Doctor' as 'Teacher'

2.) Think about Thinking (human memory specifically)

3.) Generate more questions than provide answers

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Thank you!

~Intermission~

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BONUS SLIDES!

- Time permitting (aka, how much caffeine has been consumed?)
  - LD50 for Caffeine is ~150-200 mg/kg in humans

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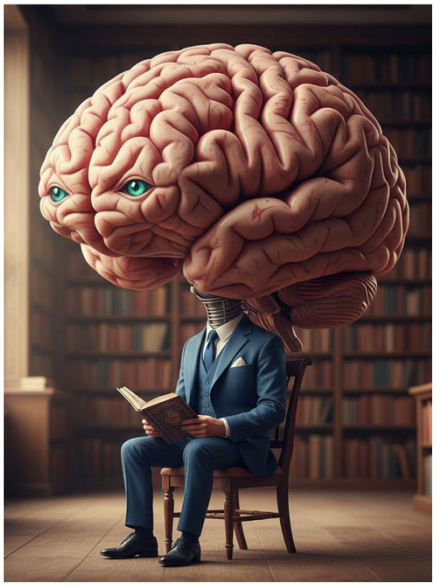
Energy of Thinking …

The human brain constitutes only about **2% of the total body mass**.

- Despite its small size, it consumes roughly **20% of the body's total basal metabolic rate (BMR)**, making it the single most energetically expensive organ in the body.
- *Analogy:* This is equivalent to approximately **260-350 kilocalories (kcal)** per day for an average adult, or a continuous power drain of about **17 watts**—the output of a dim light bulb.



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Where is the energy going?

The vast majority of this basal energy is consumed by **"housekeeping"** functions that must operate continuously, regardless of conscious thought.

75% to 80% of the brain's energy is used for non-cognitive, signaling-related processes:

Maintaining Membrane Potentials: Over half of the brain's energy is used by the **sodium-potassium pumps** to actively maintain the electrical gradients that keep neurons primed and ready to fire.

Information Processing (Basal): Consuming and sending constant baseline neural signals, even during rest or sleep.

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Does it really cost much to think?

- Engaging in complex mental tasks like solving math problems, logical reasoning, or intense studying **does not dramatically increase whole-brain energy consumption**.
- **Minimal Increase:** Performing a demanding cognitive task increases the **whole-brain energy expenditure by only a modest degree.** The increase is typically estimated to be **no more than 5%** above the brain's already high basal metabolic rate.
- *Example:* If the resting brain uses 300 kcal/day, an actively thinking brain might use around 315 kcal/day.

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Local vs Global Cost, and Redistribution

The increased energy use is often a matter of **regional reallocation** rather than a global energy surge.

Task-Specific Activation: The increase primarily reflects a higher metabolic rate in the **specific brain regions** recruited for the task (e.g., the prefrontal cortex for executive function).

For example, increased activity in the visual cortex during a visual task might be partially **offset by reduced activity** in less-relevant areas, like the auditory cortex.

Regional Increase: The energy consumption within a specific, active region may increase by up to , but because this only involves a small fraction of the total brain volume, the overall whole-brain increase remains minimal.

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The Mental Fatigue Paradox

- If the caloric increase is so small, why do we **feel mentally exhausted** after complex tasks?
- The feeling of fatigue is likely **not** due to running out of calories/glucose
- **Alternative Explanations for Fatigue:**
  - **Build-up of Metabolic Byproducts:** Neurotransmitters and metabolic waste products accumulate in active brain regions, which may signal a need to rest or reallocate resources.
  - **Stress and Arousal:** Complex tasks often induce **stress**, which triggers a whole-body response (increased heart rate, muscle tension, cortisol release), accounting for measurable whole-body energy increases *outside* of pure cognitive cost.
  - **Motivation and Trade-offs:** The brain evolved to be energetically **frugal**. The cost of even a small increase, if sustained, was significant in an ancestral environment. The feeling of "effort" may be an adaptive mechanism to conserve this resource and prompt the organism to prioritize.
- The high **absolute** cost of the brain (20% of BMR) is mainly due to its **continuous, baseline functional maintenance**. The **marginal** cost of complex thought is surprisingly low.

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Resources for Brain-Energy Discussion

- **Padamsey, Z., et al. (2021).** *The Brain Energy Landscape: Metabolic Regulation of Neuronal Activity.* Trends in Neurosciences, 44(8), 654-666. (Discusses the high baseline cost and trade-offs)
- **Dukas, R., & Fawcett, T. W. (2018).** *Cognitive cost and its effects on decision making.* Trends in Ecology & Evolution, 33(3), 196-204. (Discusses the evolutionary constraints and trade-offs in cognitive cost.)
- **Attwell, D., & Laughlin, S. B. (2001).** *An energy budget for signaling in the grey matter of the brain.* Journal of Cerebral Blood Flow & Metabolism, 21(9), 1133-1145.
- **Clarke, D. D., & Sokoloff, L. (1999).** *Appraising the brain's energy budget.* Proceedings of the National Academy of Sciences, 96(23), 12975-12977.
- **Raichle, M. E., & Gusnard, D. A. (2002).** *Appraising the brain's energy budget.* Proceedings of the National Academy of Sciences, 99(16), 10237-10239

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No Fellow Left Behind

MHI Grand Rounds
December 15th, 2025
James Evers, MD

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Outline

THE NATURE OF THE PROBLEM

HOW TO LEARN AND REMEMBER

NO FELLOW LEFT BEHIND

BECOMING AN ASSET

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Gratefulness Statement

- "Any fool can criticize, condemn, and complain, and most fools do." – Dale Carnegie

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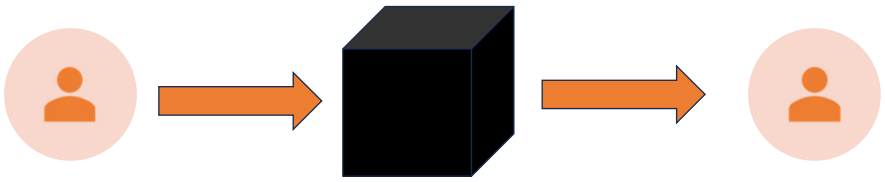
Re-align with the purpose of education



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Provider Skills

Knowledge

The summation of pieces of information, learned pattern recognition, and experience which aids the provider in advising a patient and his/her family.

- Teaching skills
- Communication skills
- Responding to Emotion
- Behavioral/Lifestyle Guidance

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Obligatory AI comment

- True or False

As the price of knowledge gets cheaper, the value proposition of a provider will slowly shift towards soft skills and away from content expertise.

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Question

Google Search launched on Sep 4, 1998.

Has decision-making become more straight forward, or more challenging?

- Would you be more or less likely to pay for consulting or advice services
  - Financial advisor, realtor, business consultant, interior designer, accountant, etc.

Why?

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When information is ubiquitous, why seek advisement?

- Am I missing something (FOMO)
  - You don't know what you don't know
- Does this information apply to me? (contextualization)
  - Relevance / Urgency / Importance
- Are there more efficient ways of doing this (optimization)
- I don't want to take the time to learn / apply (convenience)

- In summary, as knowledge goes up, expectations go up.

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Provider Skills

Knowledge

- Teaching skills
- Communication skills
- Responding to Emotion
- Behavioral/Lifestyle Guidance

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THE NATURE OF THE PROBLEM

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Medical Knowledge Doubling Time

1950	50 years
1980	7 years
2010	3.5 years
2020	73 days

" Students who graduate in 2020 will experience four doublings in medical knowledge by the time they complete the minimum length of training (7 years) needed to practice medicine. What was learned in the first 3 years of medical school will be just 6% of what is known at the end of the decade from 2010-2020."

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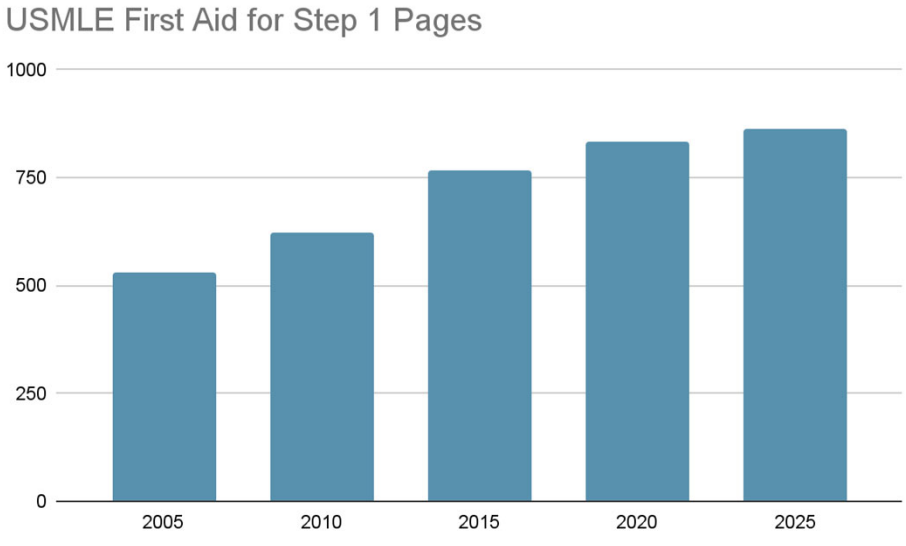

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HOW TO LEARN
AND REMEMBER
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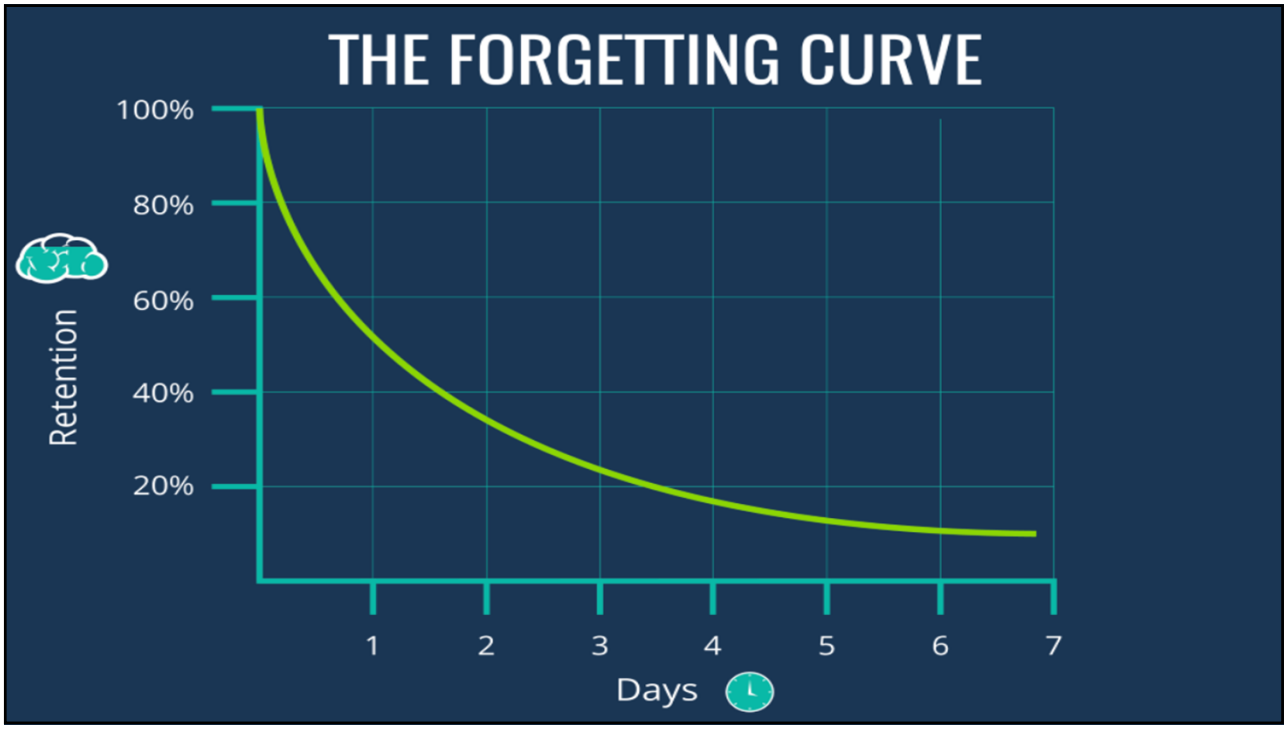
THE FORGETTING CURVE
100%
80%
60%
40%
20%
Retention
1
2
3
4
5
6
7
Days

56

Combatting the Forgetting Curve

- Encoding
  - Context - New info fits within your own personal schema
  - Relevance – You can imagine how it would apply practically
  - Difficulty – Enough old stuff, enough new stuff
- Active Recall / Retrieval
  - Interactive / Not Passive
- Spaced Repetition
- Chunking / Microlearning
  - Information overload can be counterproductive

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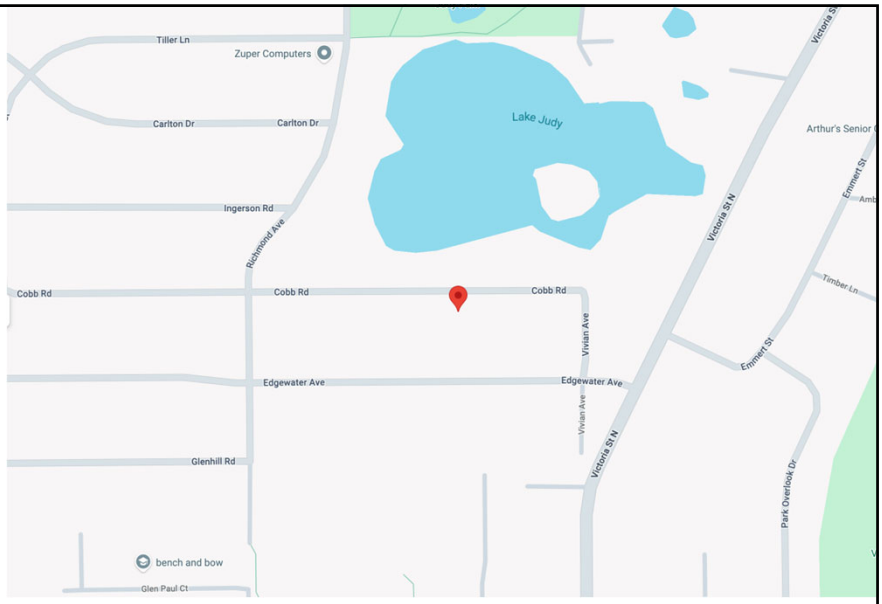
Context



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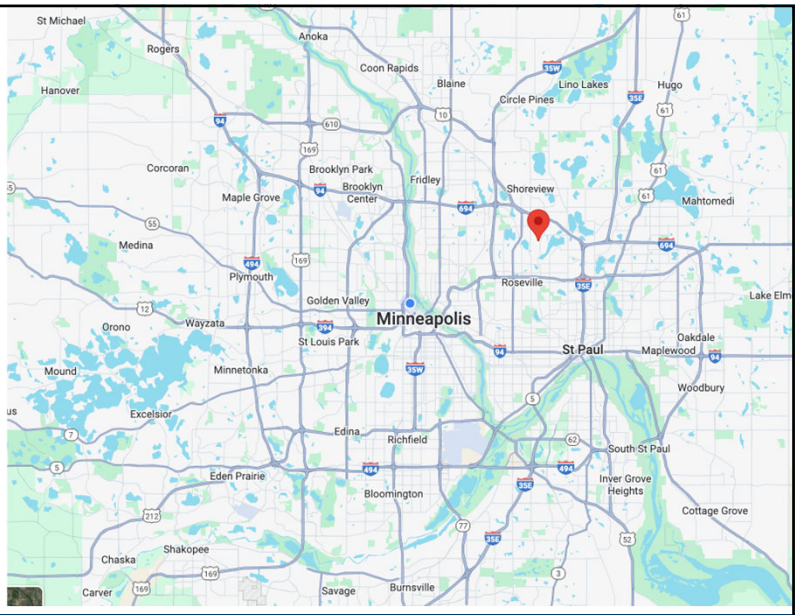
Context



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Relevance

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Difficulty

Samara's Hypoplastic Left Heart Syndrome lecture

Takeaways – I need to learn about HLHS

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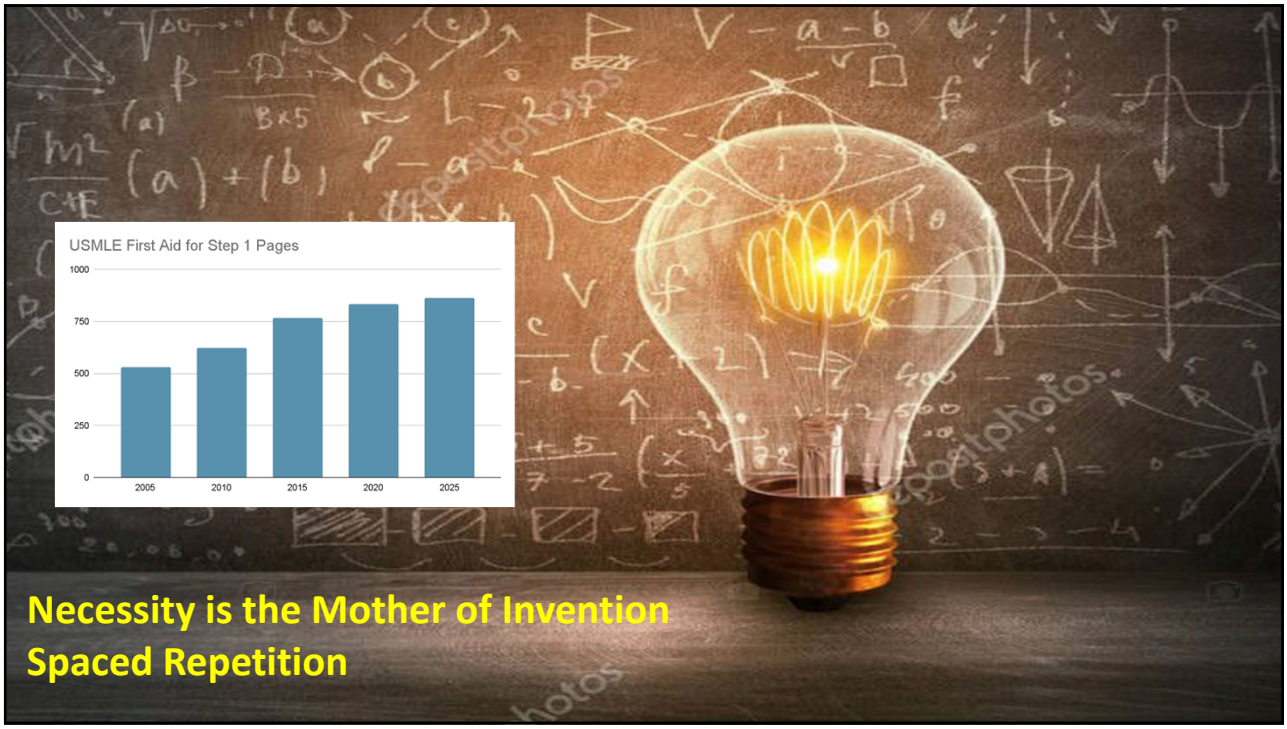

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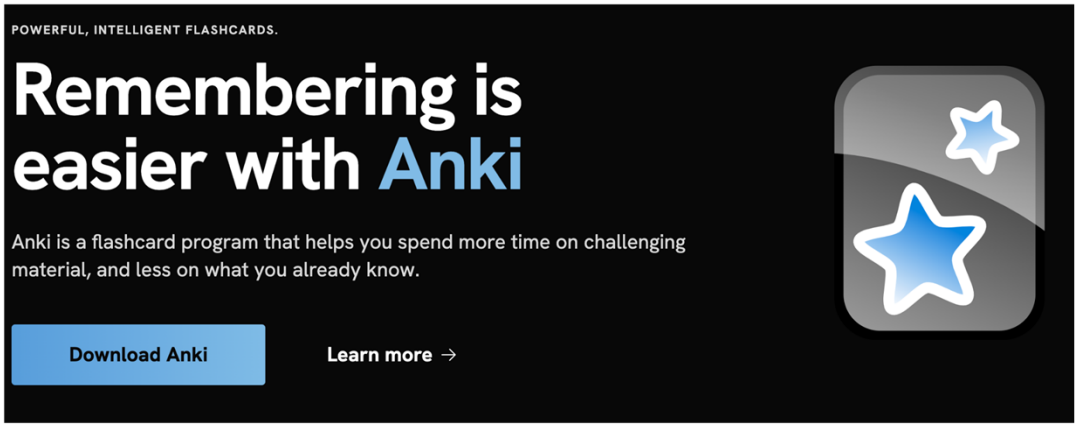
Spaced Repetition



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Anki

- Advanced Flashcard Software Service
- Incorporates Difficulty-based spaced repetition
  - Incorrect → sooner
- Combination of Self-Made and open source flashcards
- Popular AnKing Deck has 30,000 flashcards providing a comprehensive study pathway for medical students for board exams
- Around test times students are going through up to 1000 flashcards per day

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Evidence for Anki?

- Cohort Control study 130 medical students (2021)
- 78 used Anki , 52 did not
- Anki users scored 6.2-7% better on course exams
- Anki users scored 13% better on CBSE (MOCK STEP 1) exams
  - p = 0.003
- Regardless of MCAT score
- Self reported reliance on Anki was correlated higher test scores

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Learning Takeaways

- Learning (Encoding)
  - Must meet you where you're at (Context/Relevance/Difficulty)
  - Broad → Narrow = conceptual → Specific
- Remembering = Context appropriate information retrieval
  - Spaced Repetition
  - Interactive (Retrieval vs. exposure)

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This isn't a test

- Everything we've discussed so far has essentially come from knowledge of test taking, which tends to be short term oriented
- Long term memory requires…..

- That you enjoy it

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Spaced Repetition and Gamification

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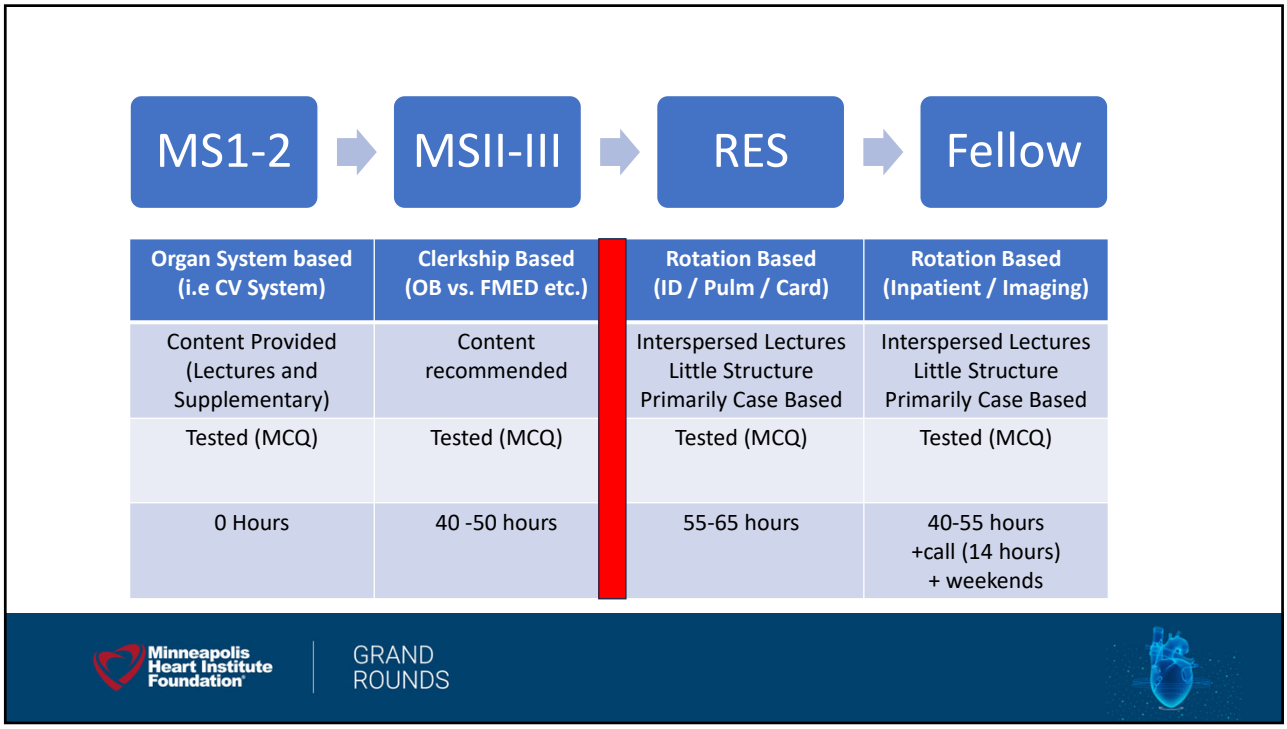
MS1-2
MSII-III
RES
Fellow
Organ System based (i.e CV System)
Clerkship Based (OB vs. FMED etc.)
Rotation Based (ID / Pulm / Card)
Rotation Based (Inpatient / Imaging)
Content Provided (Lectures and Supplementary)
Content recommended
Interspersed Lectures
Little Structure
Primarily Case Based
Interspersed Lectures
Little Structure
Primarily Case Based
Tested (MCQ)
Tested (MCQ)
Tested (MCQ)
Tested (MCQ)
0 Hours
40 -50 hours
55-65 hours
40-55 hours
+call (14 hours)
+ weekends
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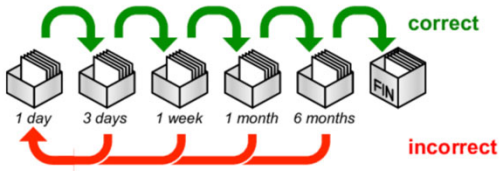
Sample Clinical Rotations: PG-1 Year

Each block = 2 weeks

1a	1b	2a	2b	3a	3b	4a	4b		
Outpatient	UW GMED	UW GMED	Elective	Outpatient	VA ED	VA Night Float	Geriatrics		
5a	5b	6a	6b	7a	7b	8a	8b		
Outpatient	UW Cardiology	UW Cardiology	Vacation	Outpatient	UW GMED	UW GMED	Elective		
9a	9b	10a	10b	11a	11b	12a	12b	13a	13b
Outpatient	MICU	MICU	Elective/ Vacation	Outpatient	VA GMED	VA GMED	Elective	Outpatient	Heme Wards



Spaced repetition with flashcard learning: Repetition intervals increase for subsequent boxes.

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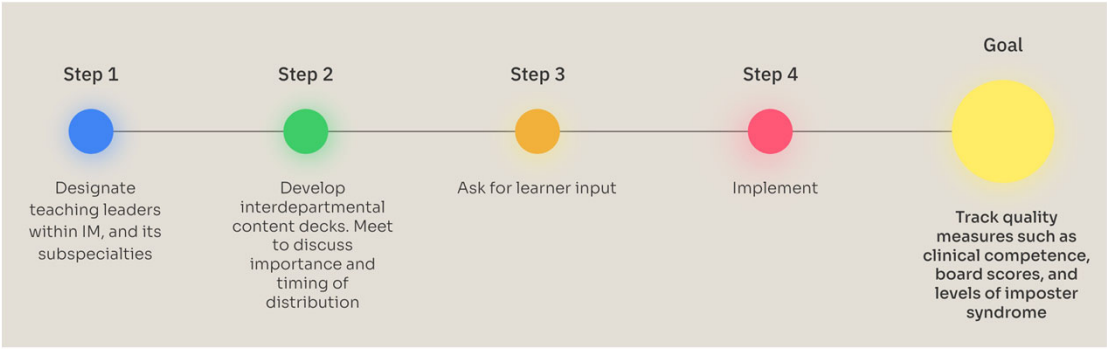
Flashcard creation and ilteration



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Systematically

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Interns	C	C	C	C
PGY2	C	C	I	I
PGY 3	I	I	I	I

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BECOMING AN ASSET

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Summary

- Knowledge is becoming ubiquitous. (Paradox)
- Expectations for content expertise are rising.
- Incredible tools exist for encoding and retaining knowledge.
- Operationalizing these tools can lift you to your own expectations and far beyond.

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Citations

Gilbert MM, Frommeyer TC, Brittain GV, Stewart NA, Turner TM, Stolfi A, Parmelee D. A Cohort Study Assessing the Impact of Anki as a Spaced Repetition Tool on Academic Performance in Medical School. Med Sci Educ. 2023 Jul 1;33(4):955-962. doi: 10.1007/s40670-023-01826-8. PMID: 37546209; PMCID: PMC10403443.

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