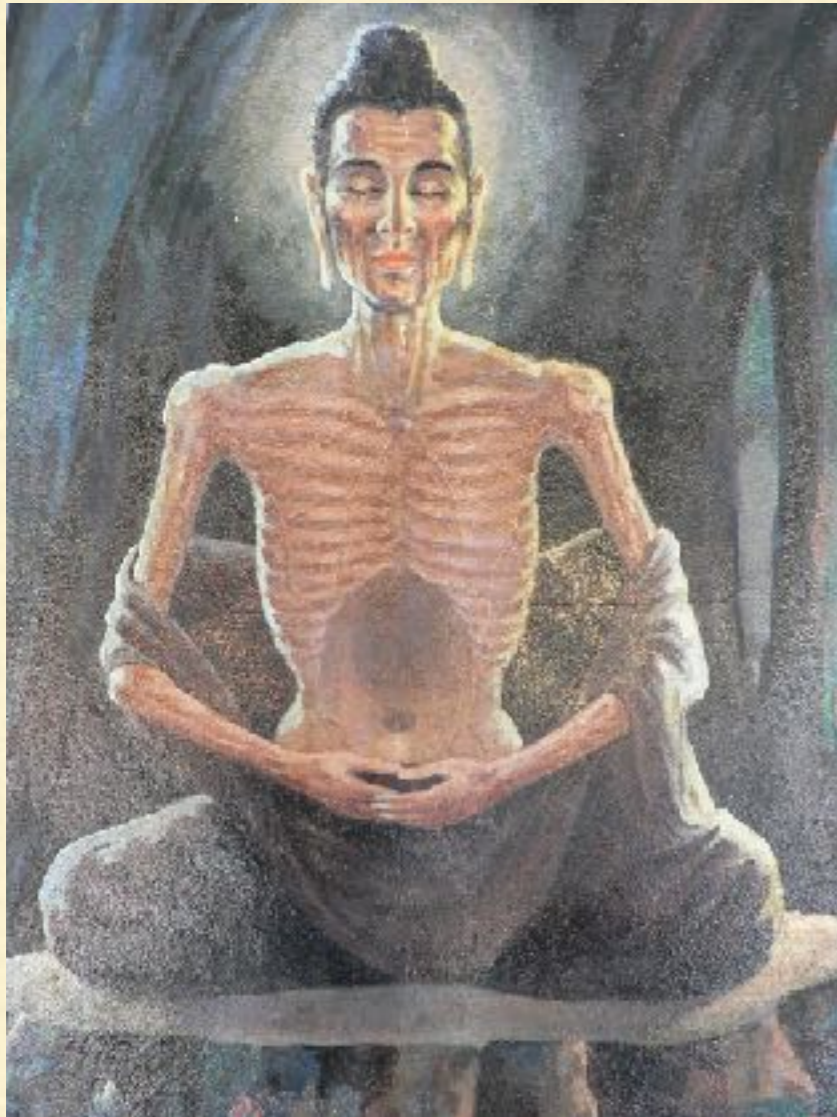


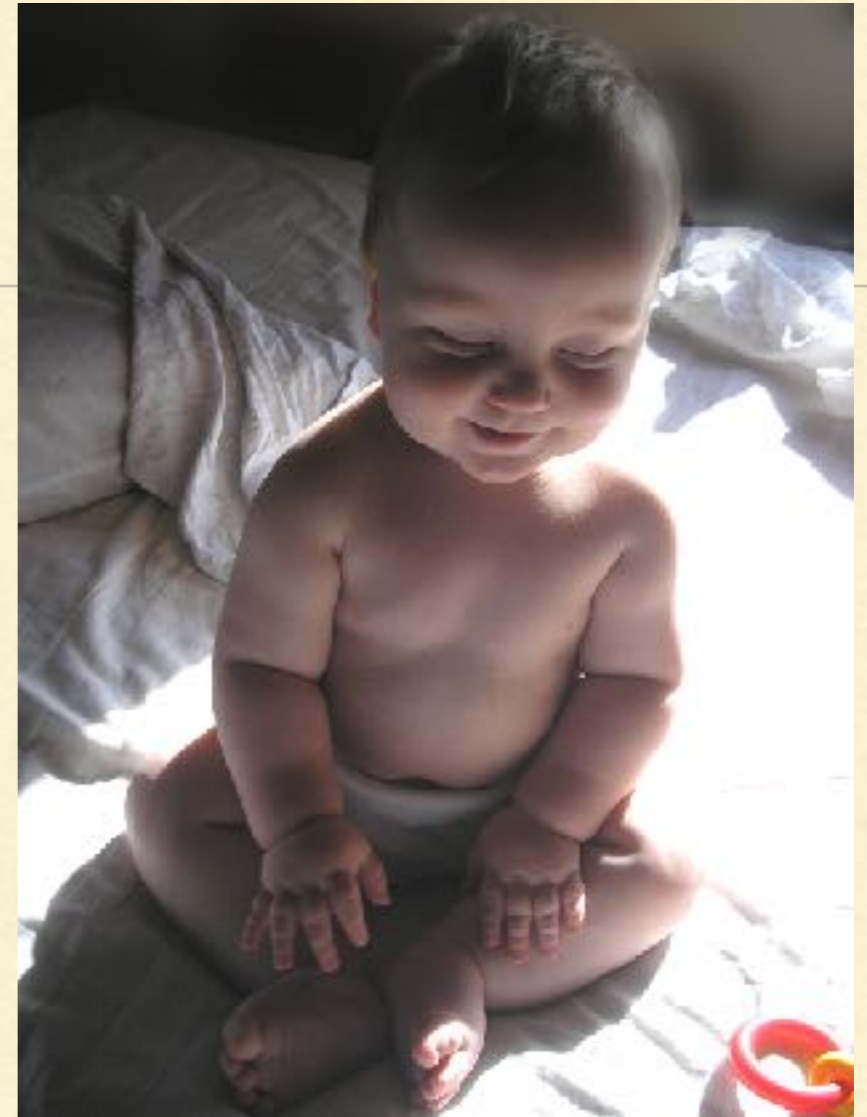
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# KETOSIS WITHOUT STARVATION: THE HUMAN ADVANTAGE

Low Carb Breckenridge 2018  
L. Amber O'Hearn



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# DISCLOSURES

Patreon support: [https://www.patreon.com/l\\_amber\\_ohearn](https://www.patreon.com/l_amber_ohearn)

The image shows a screenshot of a Patreon profile page for L. Amber O'Hearn. The page layout includes a top navigation bar with the Patreon logo, a search bar, and links for 'Create On Patreon', 'Explore Creators', 'Sign Up', and 'Log In'. The main header area features a large banner image with a scientific diagram of brain evolution on the left, a painting of a mammoth and hunters in the center, and a close-up of hands chopping meat on a wooden board on the right. A text overlay on the banner reads: 'L. Amber O'Hearn is creating science journalism: blog posts, audio streams, and books'. Below the banner is a circular profile picture of L. Amber O'Hearn and three navigation tabs: 'Overview' (selected), 'Posts', and 'Community'. A prominent red button labeled 'BECOME A PATRON' is located on the right side of the page. The 'Overview' section displays '38 patrons' and '\$356 per month'. A bio section contains the text: 'Greetings! My name is Amber O'Hearn. Although I'm a data scientist by profession, I've been researching and experimenting with ketogenic and evolution-based diets since 1997. More recently I started writing and speaking about my findings. I have two blogs:'. To the right of the bio are social media share buttons for Facebook ('SHARE') and Twitter ('TWEET'). At the bottom right, there is a section titled 'REWARDS'.



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# "FASTING-MIMICKING DIET"

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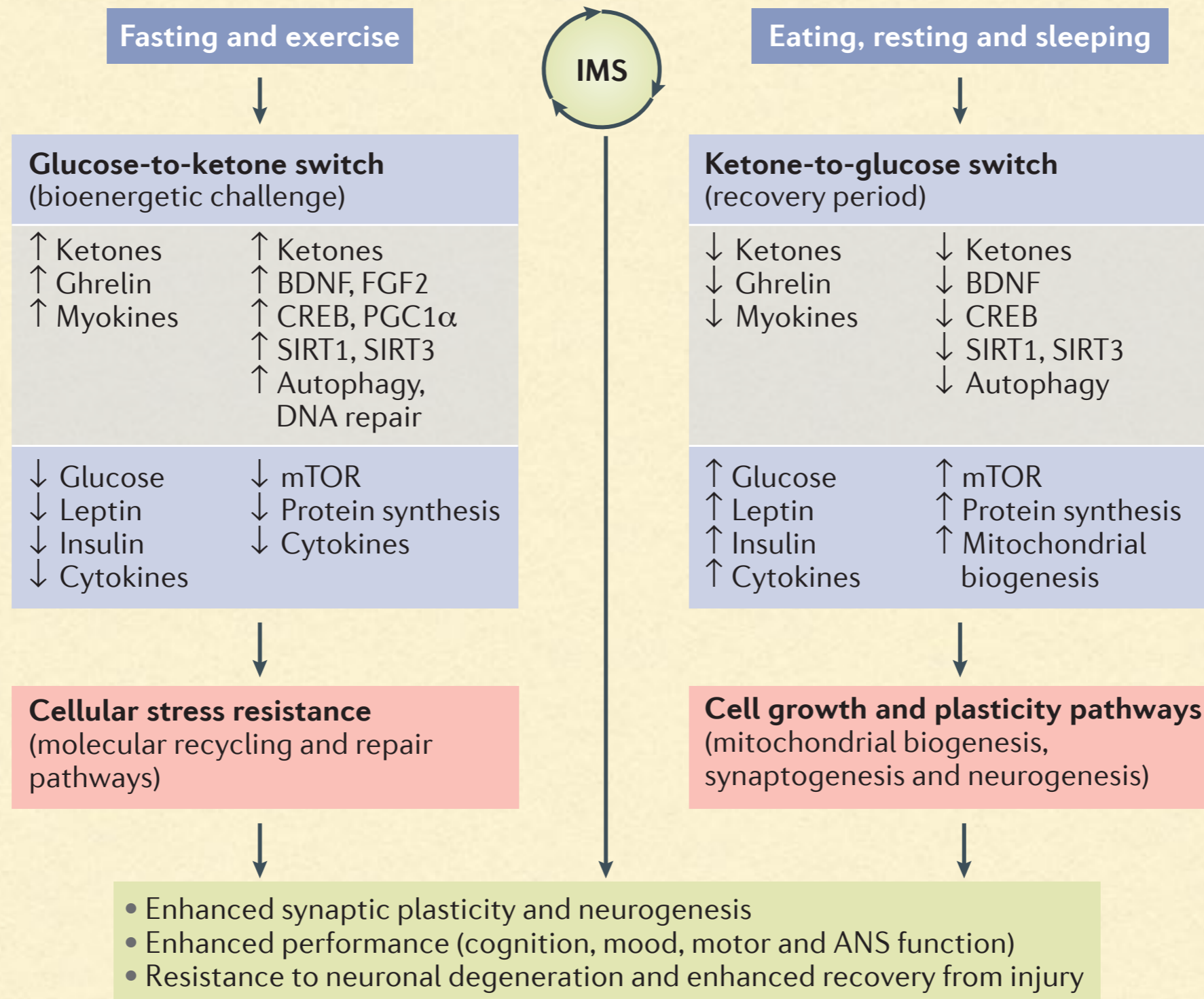


If your food looks like this, there is no ketosis unless you haven't eaten for days.

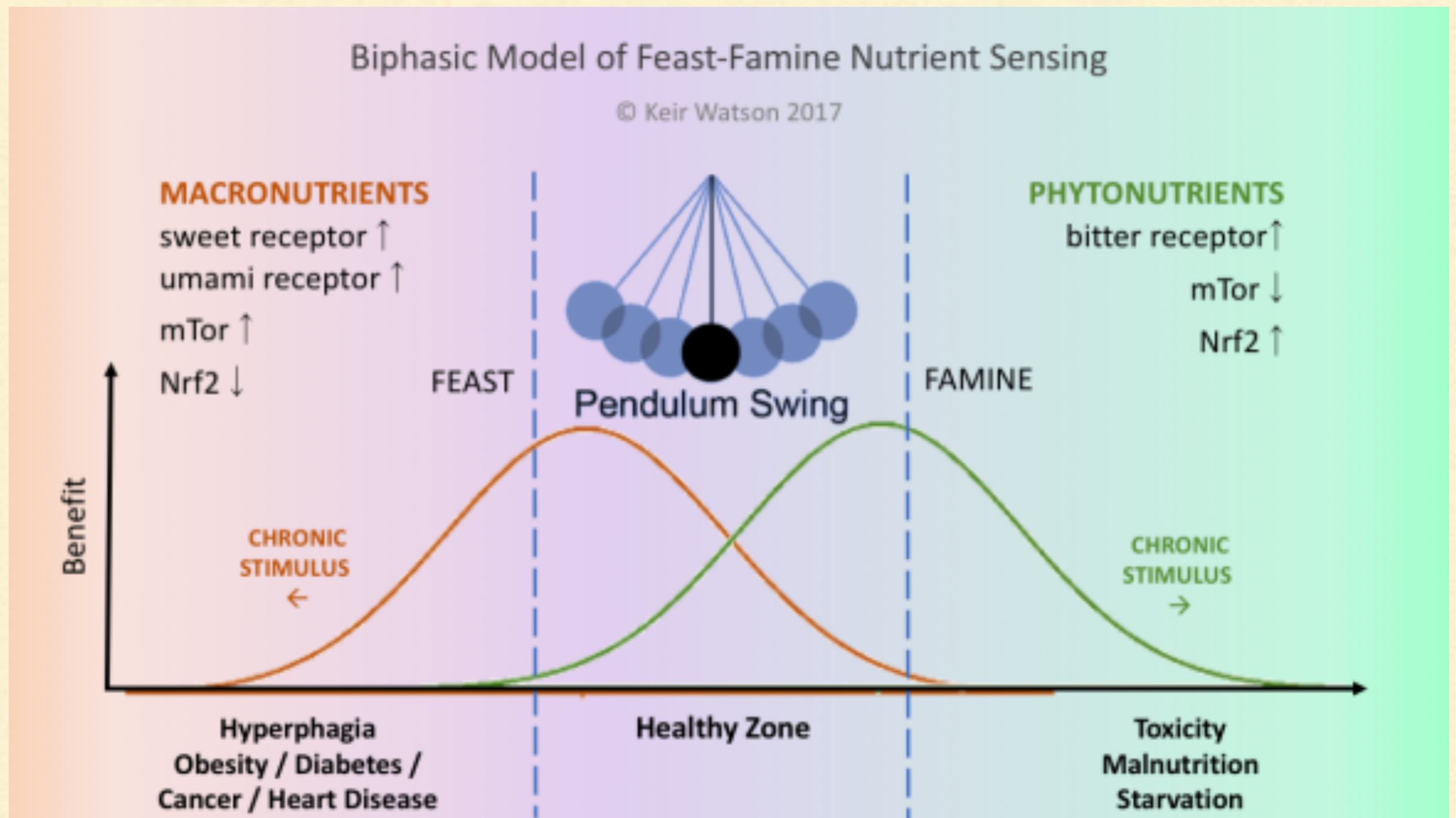
Ergo, ketosis is like fasting.



# SIGNALS: FASTING VS FED

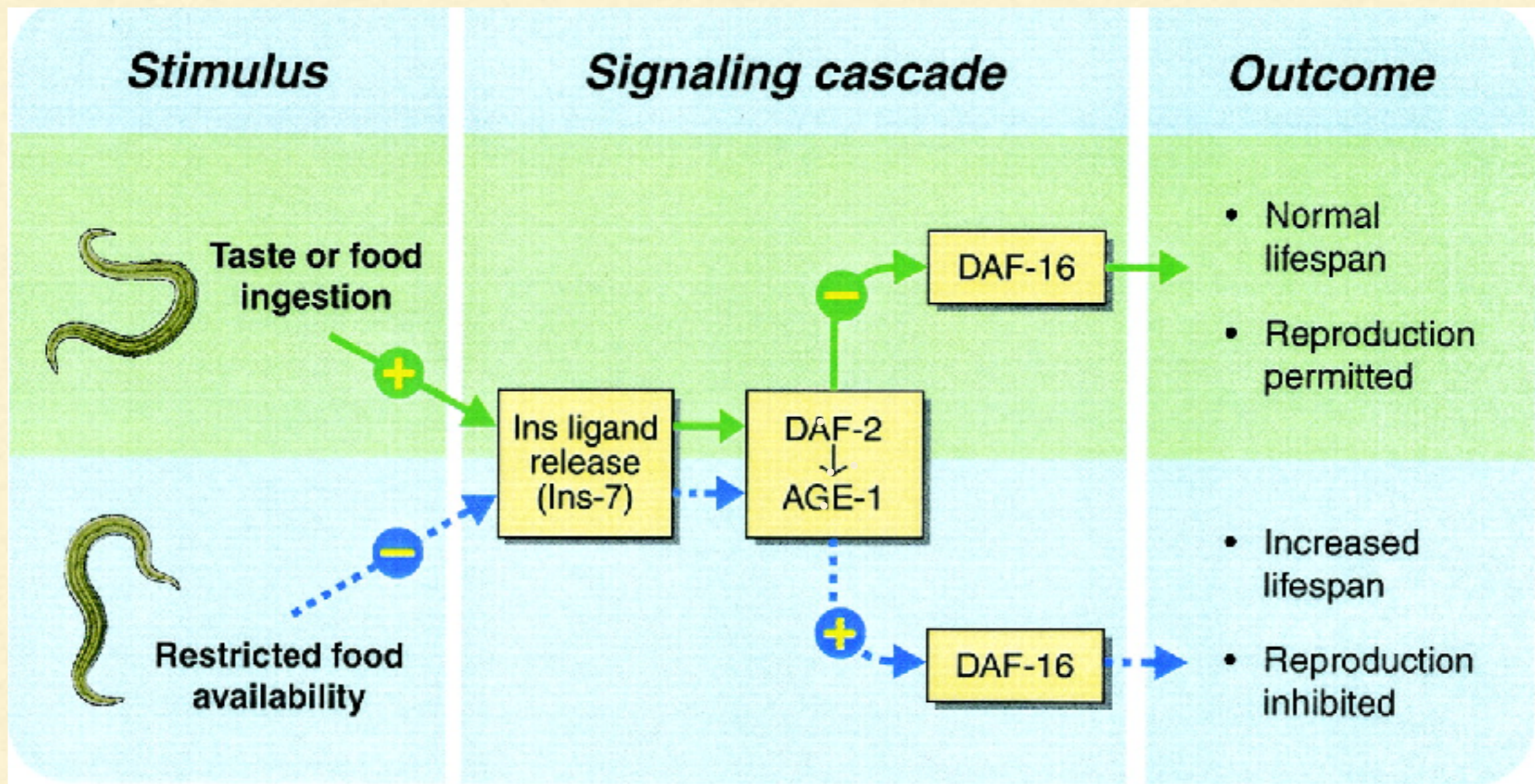


# SIGNALS: FASTING VS FED





# STARVATION COMPROMISES REPRODUCTION





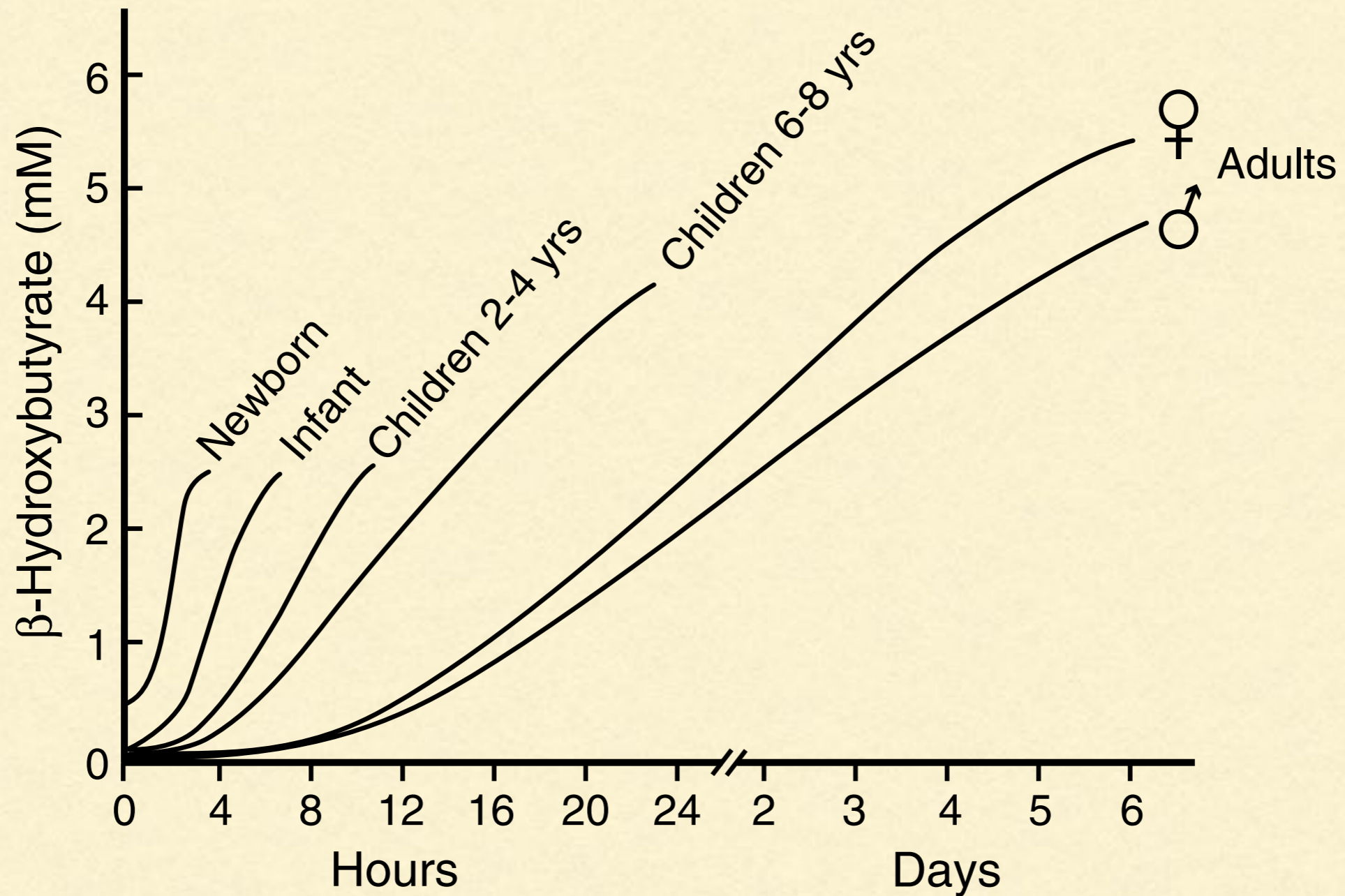
# FED STATE KETOSIS?



# CHILDREN DO IT BEST

12

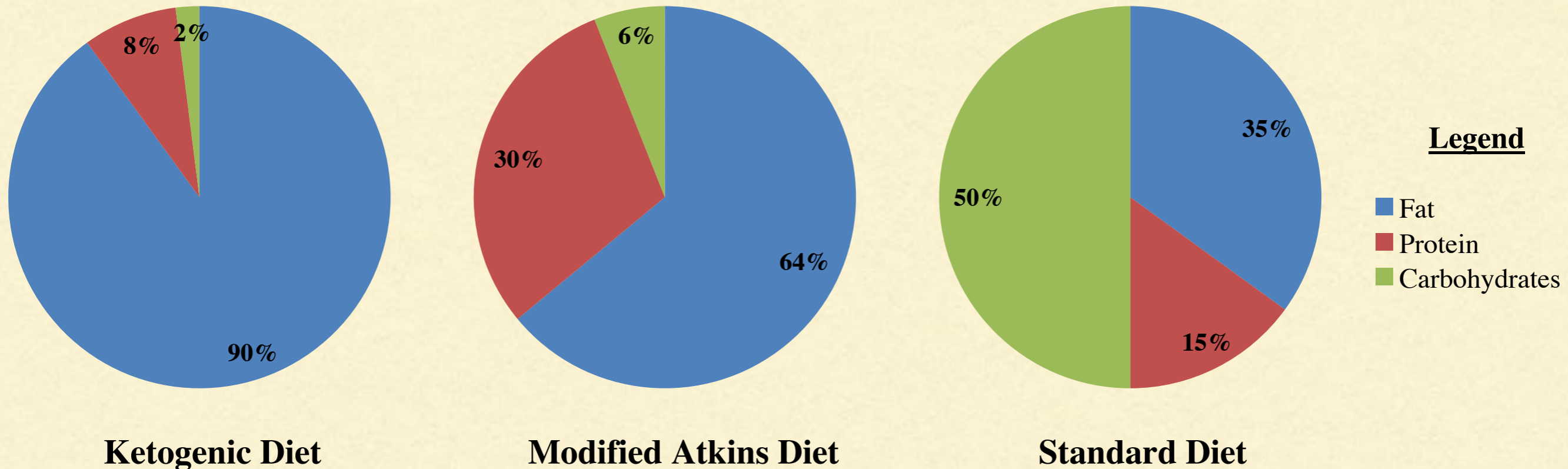
CAHILL





# “MODIFIED ATKINS DIET” IS KETOGENIC

*E.H. Kossoff et al. / Epilepsy & Behavior 29 (2013) 437–442*



**Fig. 1.** Differences between the macronutrient compositions among the diets.

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# ADULTS: KETOGENIC WITH ADEQUATE PROTEIN WHAT'S ADEQUATE?

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- **RDA**

- **0.8 g/kg** body weight

- **Not enough:** By their own admission!

- In Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients) Institute of Medicine)*

- **Protein Sparing Modified Fast:**

- Reported in Multidisciplinary approach to obesity utilizing fasting modified by protein-sparing therapy. PG Lindner, GL Blackburn. Obesity/Bariatric Med, 1976, pp. 198–216)*

- **1.2 g/kg** ideal weight in females / **1.4 g/kg** ideal weight in males

- Ketogenic! But not full calorie

- **Virta Health**

- **1.5 - 1.75 g/kg** ideal weight

- Reported in <https://blog.virtahealth.com/how-much-protein-on-keto/>*

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# EVEN ADULTS: 1.5-2 X MINIMUM PROTEIN?

Study	Protein	Carbs	Ketone levels
<a href="#">Noakes et al., 2006</a> BW ~87 kg	~122.5 g 1.4 g/kg	~32.5 g	BHB+Acetoacetate (AA): ~0.5 mmol/L
<a href="#">Johnstone et al., 2008</a> BW 108 kg	123 g 1.1 g/kg	22 g	BHB 1.52 mmol/L
<a href="#">Johnston et al., 2006</a> BW 95.8 kg	125 g 1.3 g/kg	33 g	BHB 0.72 mmol/L (wk 2) 0.33 mmol/L (wk 6)
<a href="#">Wilson et al., 2017</a> BW 80 kg	~130 g 1.6 g/kg	~31 g	Blood ketones ~1 mmol/L
<a href="#">McSwiney et al., 2017</a> BW ~81.7 kg	130.7 g 1.6 g/kg	41.1 g	BHB 0.5 ± 0.4 mmol/L

Study	Protein	Carbs	Ketone levels
<a href="#">Brinkworth et al., 2009</a> BW 94.4 kg	~137 g 1.5 g/kg	~20 g	BHB 0.49 ± 0.06 mmol/L
<a href="#">Volek et al., 2016</a> BW 68.8 kg	139 ± 32 g 2.1 g/kg	82 ± 62 g	BHB+AA ~0.7 mmol/L
<a href="#">Burke et al., 2017</a>	144 g 2.2 g/kg	33 g	BHB 1.8 mmol/L
<a href="#">Fleming et al., 2003</a> 79.2 kg	176 ± 45 g 2.2 g/kg	46 ± 10 g	Serum BHB 0.29 ± 0.09 mmol/L
<a href="#">Klement et al., 2013</a> Women: ~64 kg Men: ~80 kg	Women: 147 g (2.3 g/kg) Men: 221 g (2.8 g/kg)	16.5 ± 1.1 g	Urinary ketones (AA) Median 1.5 mmol/L

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# OTHER SPECIES: DOGS?



Humans get into ketosis faster and deeper  
and with more protein

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# OTHER SPECIES: RODENTS?



For rodents, the line between adequate protein and too much for ketosis is vanishingly small

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# OTHER SPECIES: OBLIGATE CARNIVORES?



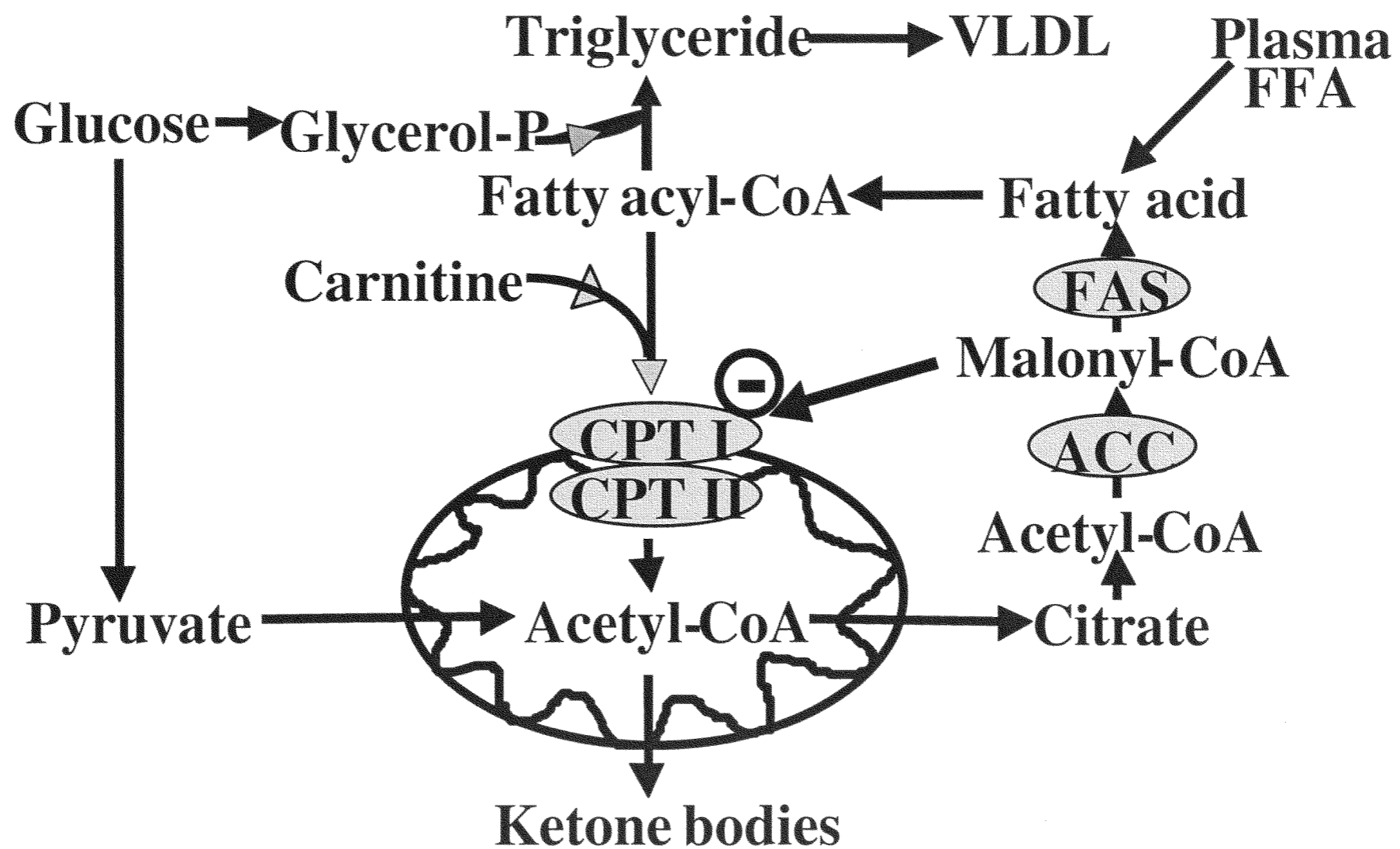
Obligate carnivores  
may not use ketosis at all  
gluconeogenesis covers it

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# MECHANISM???

## FATTY ACID SYNTHESIS AND OXIDATION IN LIVER



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# WHAT EVOLUTIONARY ENVIRONMENT

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- Significant, frequent time with little carbohydrate and ample protein?
  - Abundant access to exogenous or endogenous fat?
-



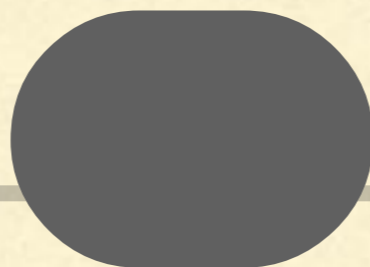
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# SELECTIVE ADVANTAGE

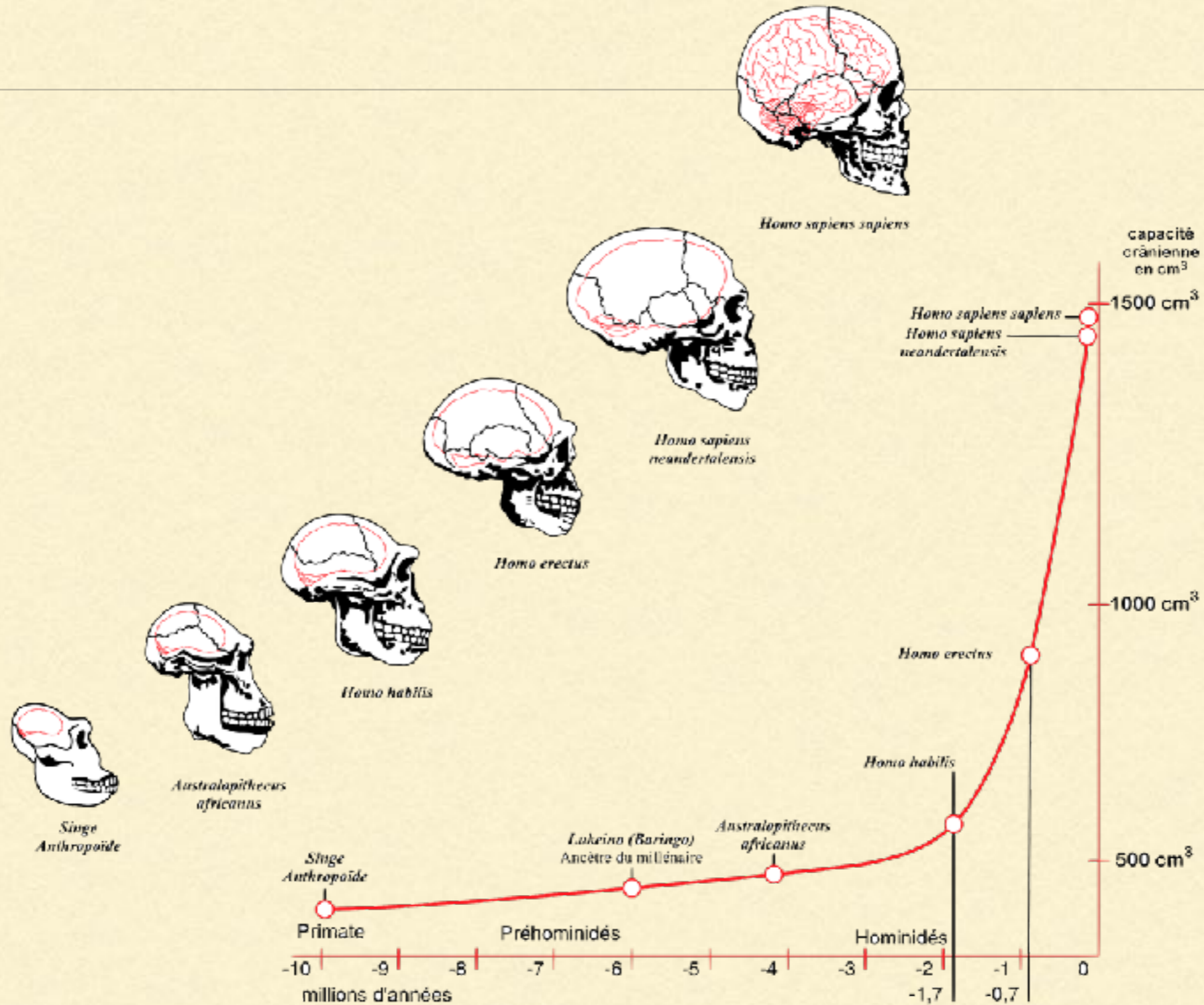


Why do we use ketosis when we have enough protein to make glucose without compromising lean mass?

Other animals continue to burn lean mass until they can fuel everything with glucose

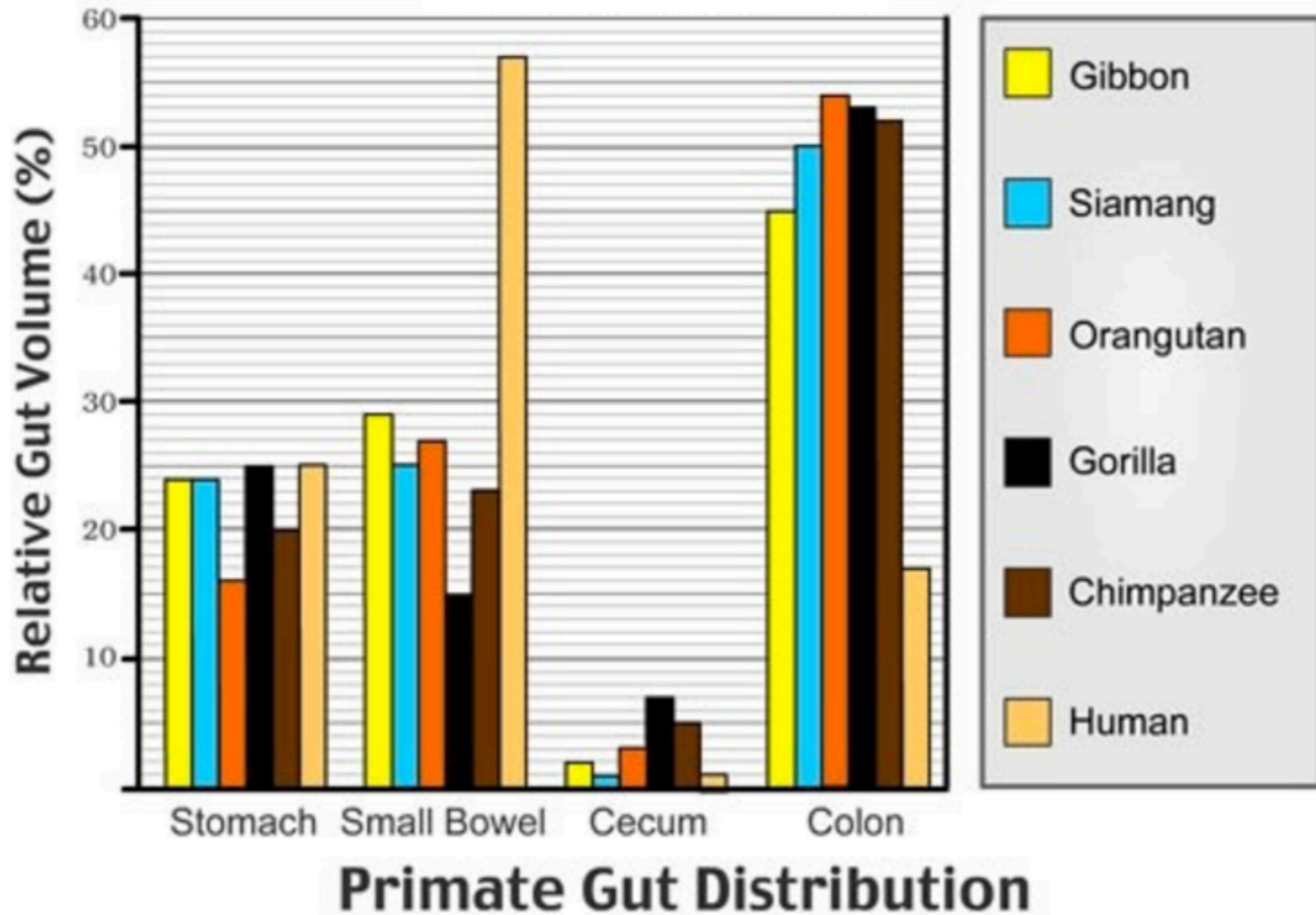


# HUMAN BRAIN EVOLUTION





# HUMAN GUT EVOLUTION



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# KETOSIS AND THE BRAIN: ENERGY

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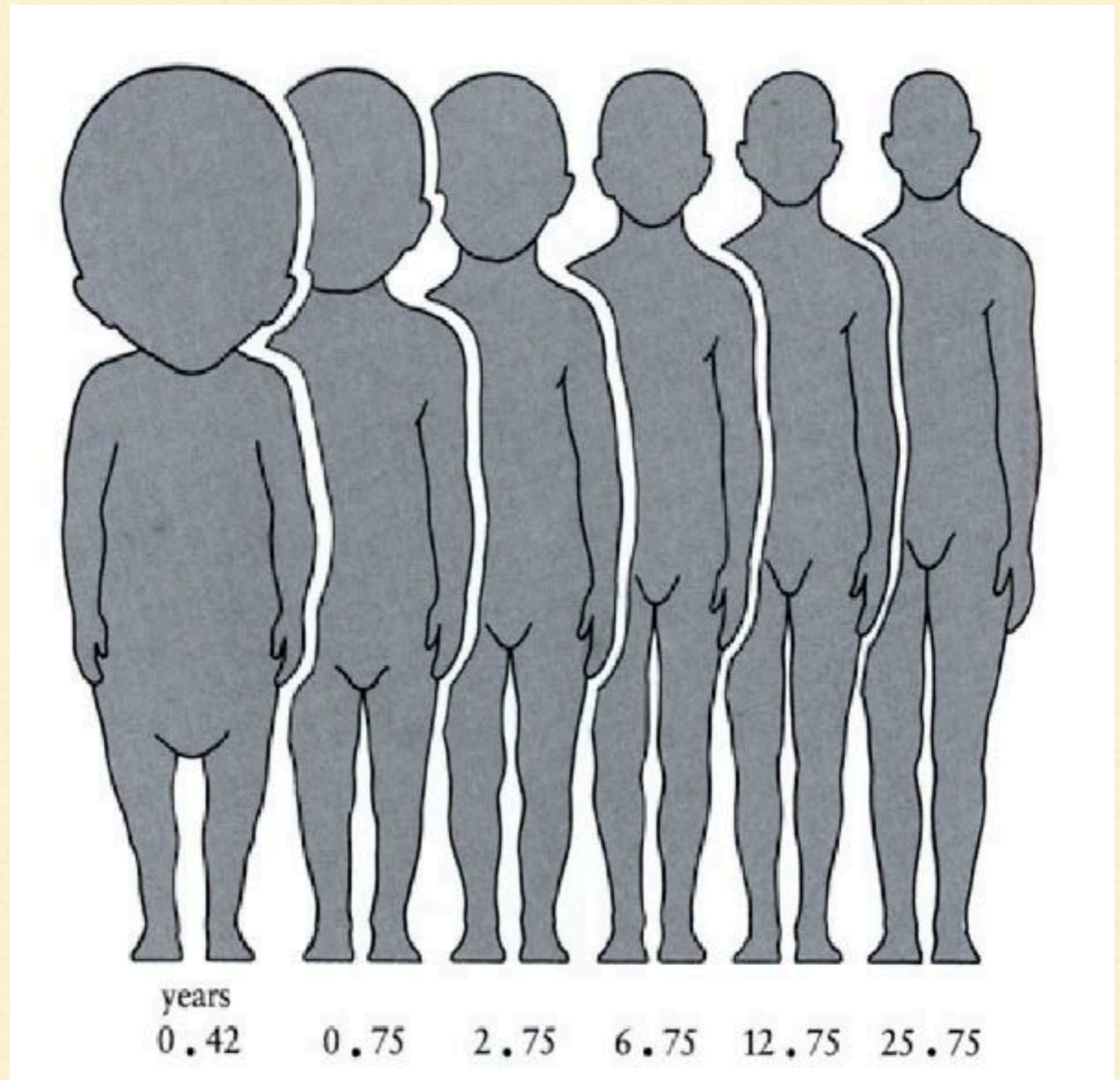
- Adult brain uses ~20% of all energy
- 40g glucose even fasting
- Takes up as ketones proportional to availability





# KETOSIS AND THE BRAIN: ENERGY

Brain/body proportion  
over the lifespan



# FATNESS AND BRAIN ENERGY USE

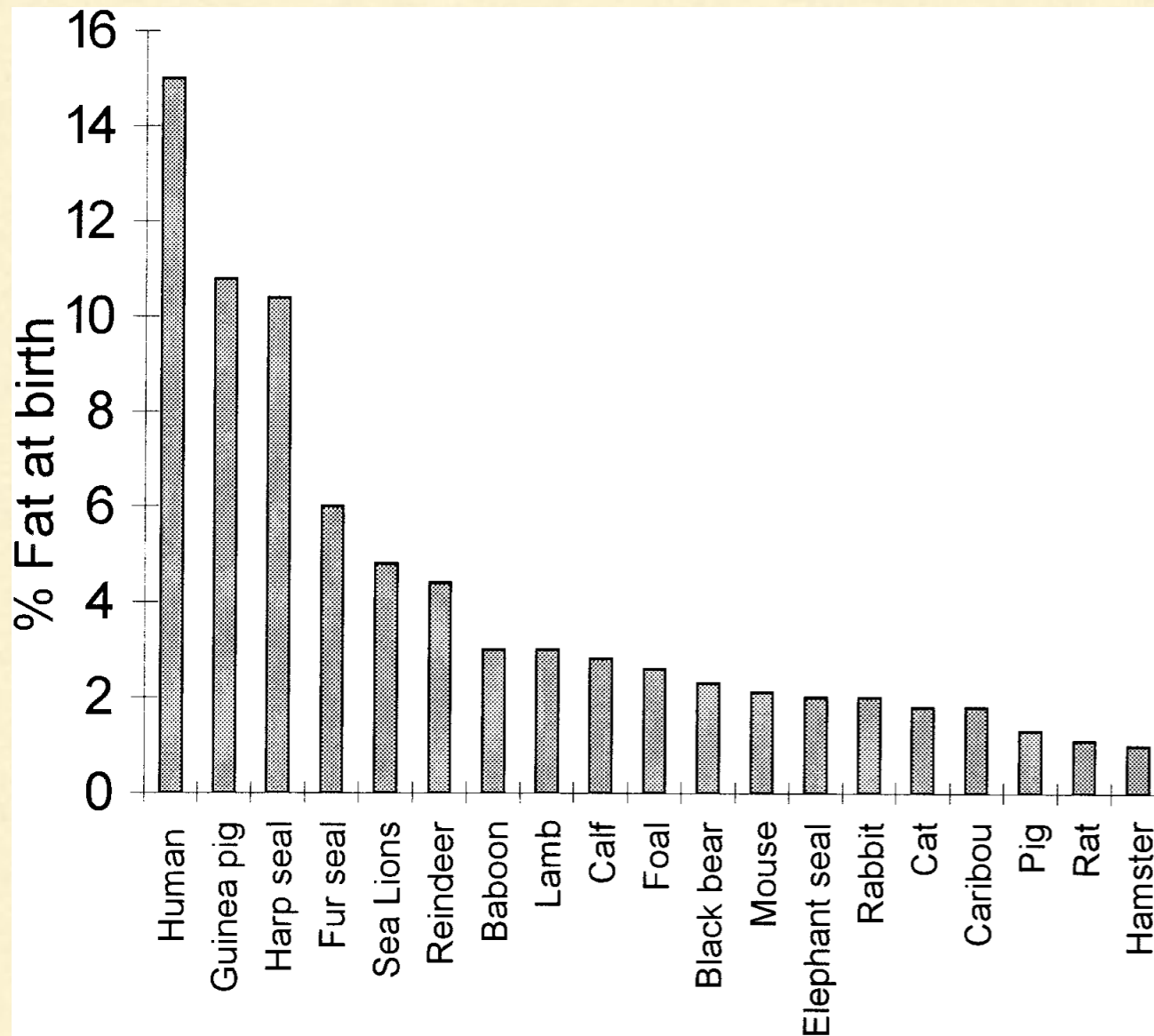


Fig. 1. Percentage fat at birth in mammals (see Table 1 for references).

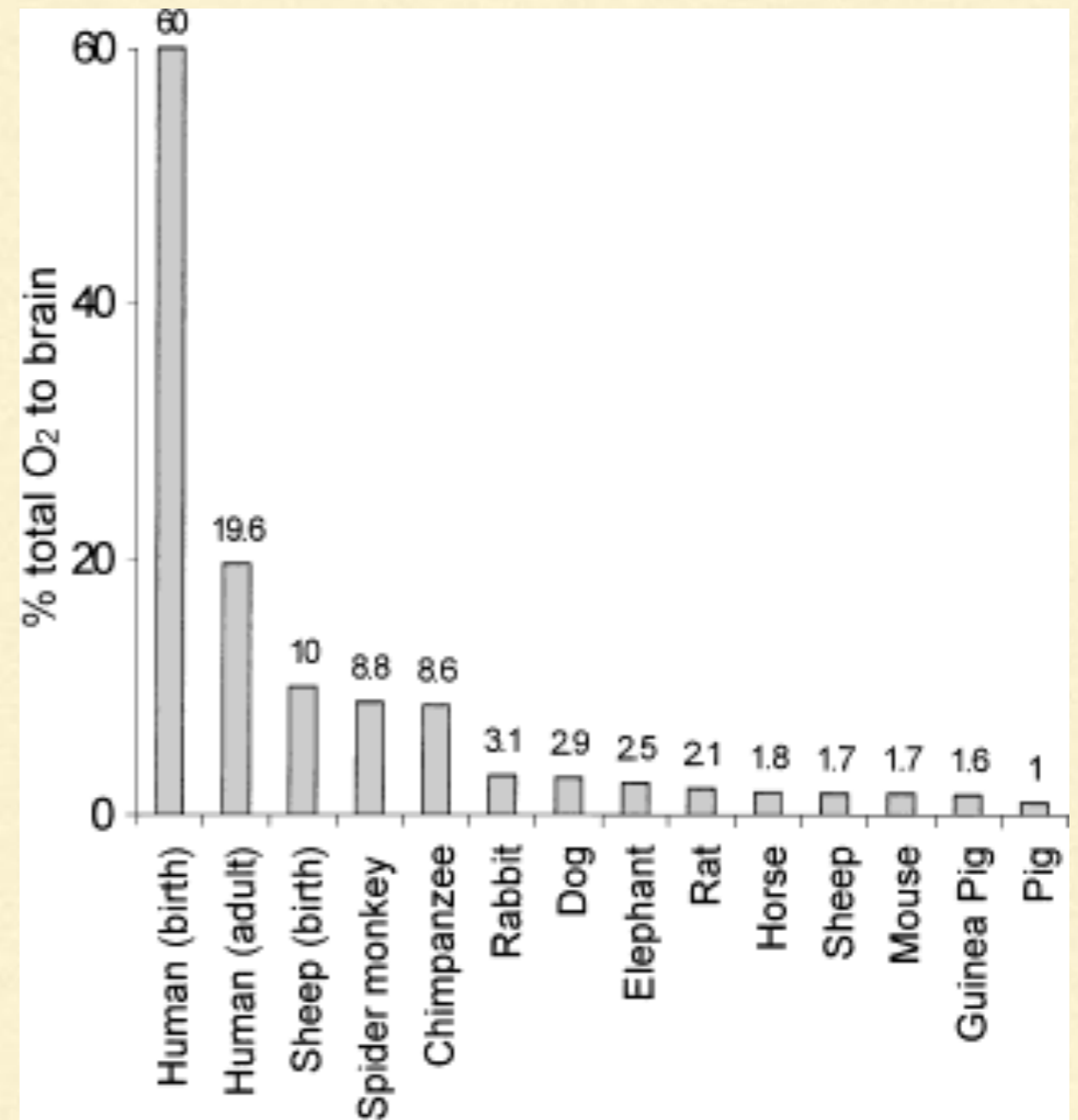
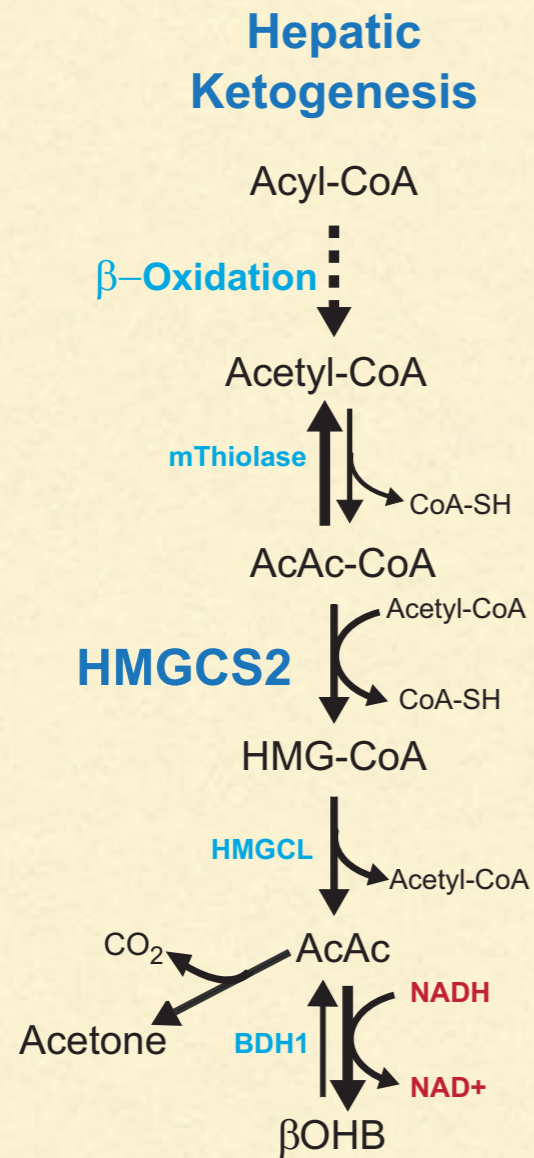


Fig. 3. Cerebral O<sub>2</sub> uptake as a percentage of total body metabolism in mammals. Humans have the largest brain size relative to body size on record and consequently devote a large proportion of total metabolism to meeting the brain's energy needs. It is hypothesized that the greater energy needs of the human brain—which must be supplied from tissue stores during nutritional disruption—may help explain why human infants invest extensively in body fat stores, including the atypical prenatal investment in the tissue (see Table 3 for data and sources).

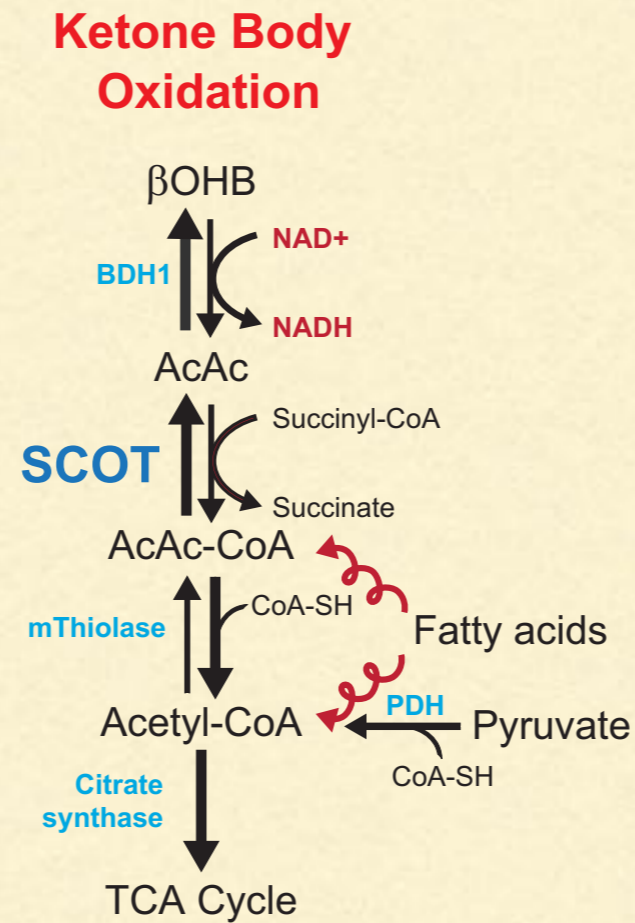


# KETONES AND THE BRAIN: STRUCTURE

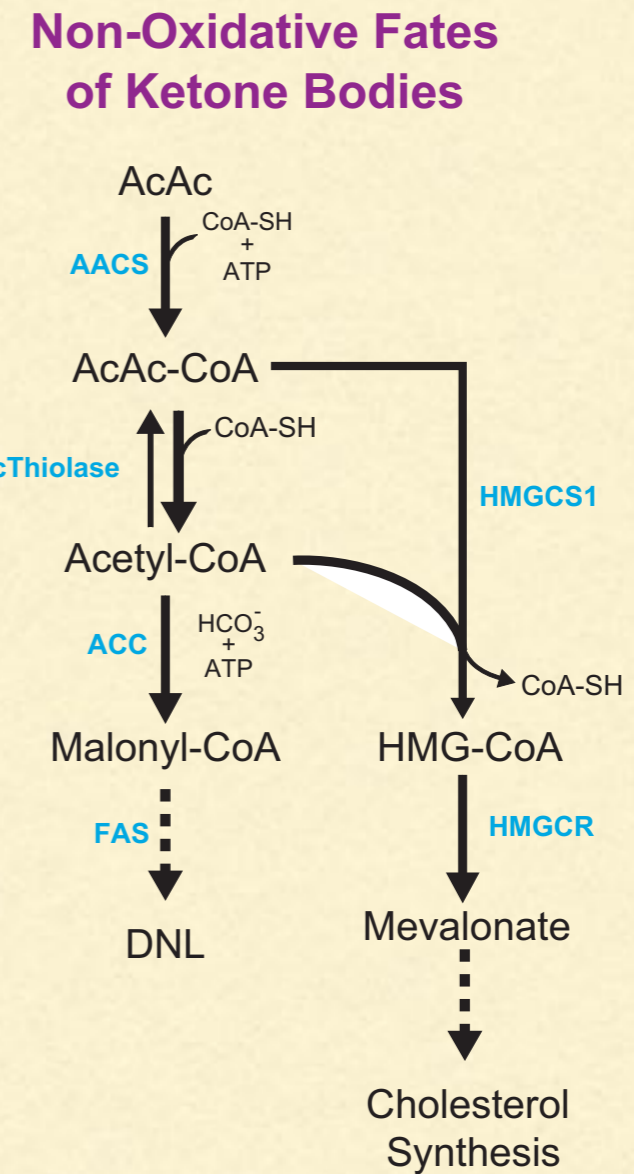
**A**



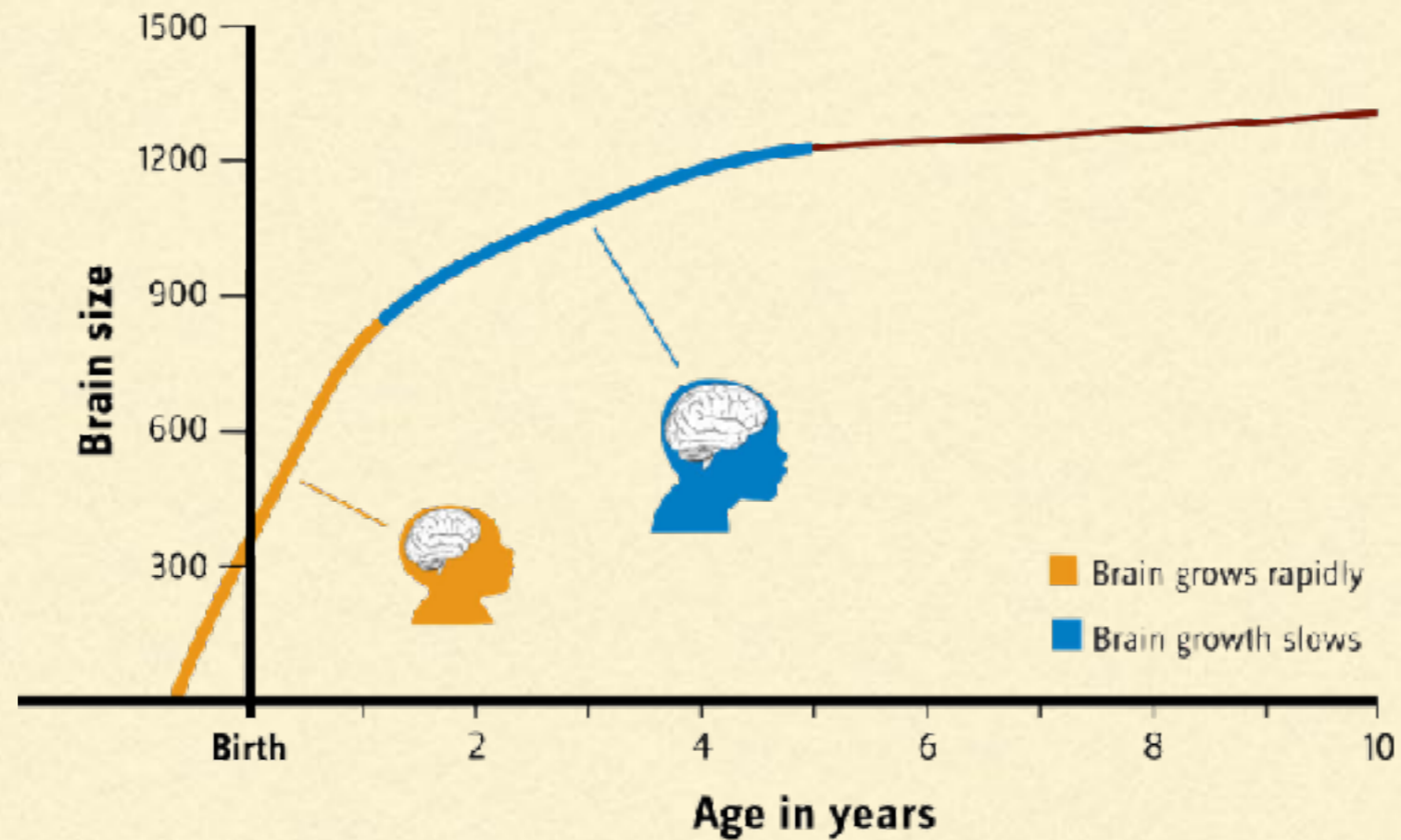
**B**



**C**



# HUMAN BRAIN GROWTH



## Dynamic mapping of human cortical development



Source: "Dynamic mapping of human cortical development during childhood through early adulthood," Nitin Gogtay et al., Proceedings of the National Academy of Sciences, May 25, 2004; California Institute of Technology.



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# YOUR BRAIN ON KETONES

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- Higher ketone bodies
  - Reduced glucose
  - Increased uncoupling proteins
  - Increased mitochondrial biogenesis
  - Decreased ROS
  - Increased glutathione
  - Neurotransmitter changes: norepinephrine, GABA, glutamate, adenosine
  - Increased plasma availability of FFA: DHA, AA
-

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# BRAIN ENHANCEMENT FROM KETOGENIC DIETS

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- Varying levels of evidence in brain health
    - Epilepsy
    - Alzheimer's, Parkinson's, ALS
    - Stroke / Trauma
    - Brain Cancer
    - Bipolar, Schizophrenia, Mood Disorders
-



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# BRAIN-GROWTH MIMICKING DIET?

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- Humans continue to generate ketones even when they have more than enough protein to supply all the brain's needs with glucose. Why?
  - We only seem to halt ketosis when we take in so much glucose we have to store it.
  - Maybe because ketosis is the “natural” state for a large brain, providing superior fuel, protection against hypoxia from trauma and oxidative stress, and it's a source of structural components.
  - Even adult human brains have plasticity
-

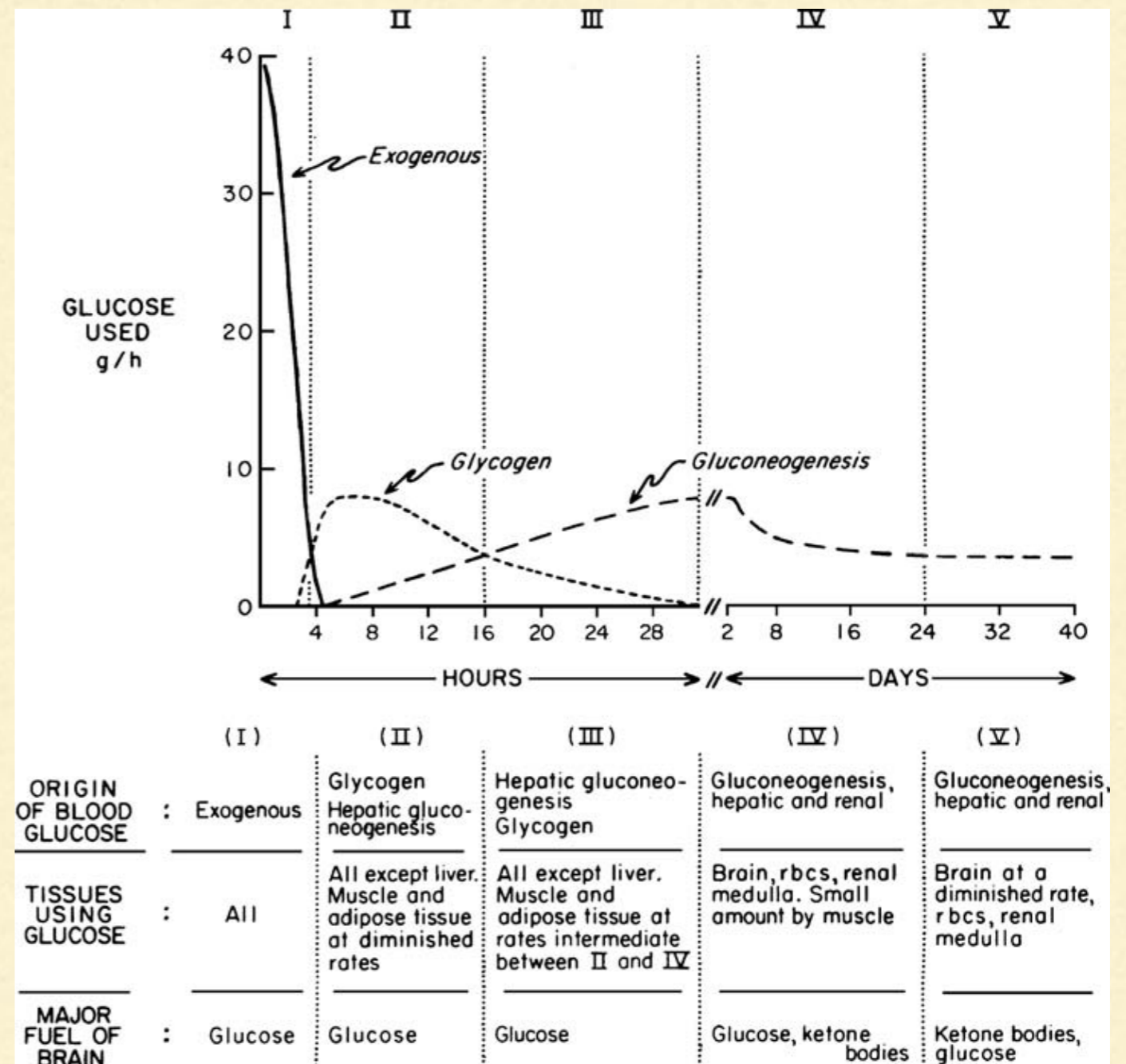
# FED VS. FASTING: BETWEEN THE LINES

In SAD, fed = absorptive phase

- 4 hours to clear out exogenous glucose
- Only then start depleting stored glycogen = postabsorptive phase

When ketogenic, absorptive phase will be short

- Glycogen stores not as full
- “Fasting” state should happen daily, even when regularly “fed”



**Figure 1** The five metabolic stages between the postabsorptive state and the near-steady state of prolonged starvation (62).



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# SUSTAINED FED KETOSIS $\neq$ STARVATION



$\neq$

