

Behavior on a Plate: The Science of Nutrition & Childhood Development

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Disclosure:

The presenter has no relevant financial relationships or conflicts of interest to disclose.

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Overview:

- Food Dyes
- Sugar and Ultra Processed Foods
- Specific Nutrients & Impact on Health & Behavior
- Big Picture: Diet Quality & Mealtime Behaviors
- What to recommend and when to refer

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Objectives:

Summarize current research findings on the effects of food dyes on behavior.

Explain the relationship between nutrient deficiencies and behavioral concerns in children.

Prioritize interventions based on clinical presentations and dietary intake.

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Interactive question



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Food Dyes

Synthetic and artificial food dyes:

Red 3 and 40

Yellow 5 and 6

Green 3

Blue No 1 and 2

Citrus Red 2

Orange B

Photo by Alexander Grey at pexels



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FDA Regulation

Safety – animal tox studies: cancer, organ damage, reproductive risk

NOAL – No Observed Adverse Effect Level
100 fold safety margin

ADI – Acceptable Daily Intake

2025: FDA revoked authorization of red no 3

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FDA Regulation

Currently phasing out artificial food dyes

The FDA is taking the following actions:

1. **Establishing a national standard and timeline** for the food industry to transition from petrochemical-based dyes to natural alternatives.
2. **Initiating the process to revoke authorization** for two synthetic food colorings—Citrus Red No. 2 and Orange B—within the coming months.
3. **Working with industry to eliminate six remaining synthetic dyes**—FD&C Green No. 3, FD&C Red No. 40, FD&C Yellow No. 5, FD&C Yellow No. 6, FD&C Blue No. 1, and FD&C Blue No. 2—from the food supply by the end of next year.
4. **Authorizing four new natural color additives** in the coming weeks, while also accelerating the review and approval of others.
5. **Partnering with the National Institutes of Health (NIH)** to conduct comprehensive research on how food additives impact children's health and development.
6. **Requesting food companies to remove FD&C Red No. 3** sooner than the 2027-2028 deadline previously required.

<https://www.fda.gov/news-events/press-announcements/hhs-fda-phase-out-petrochemical-based-synthetic-dyes-nations-food-supply>

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What is the research?

1983 Meta analysis

2004 Meta analysis – only double-blind placebo controlled

2007 Large clinical trial

2012 Meta analysis – overall variable diet restrictions on behavior

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What is the research?

2021 – OEHHA systemic review:

Out of 25 studies: 13 showed significant association between dyes and behavioral issues. Only significant for parent reports and not with teacher reports.

“Sensitivity vary greatly from person to person.

Likely that existing ADI threshold would be lower if neurobehavioral effects of animal studies were used to determine thresholds.”

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Anecdotal Reports



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What foods have artificial dyes?



Photo by ChatGPT AI

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Expectations with phasing out of dyes



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Expectations with phasing out of dyes



Photo Credit: Pascopix / Alamy Stock Photo

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Misinformation



Photo by Jane T Dat pexels

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What about sugar?

Conflicting research.

Theory:

- ❖ GI discomfort?
- ❖ Elevated blood glucose →
Reactive hypoglycemia?
- ❖ Addiction-like effects influencing neurotransmitters?
- ❖ Influence on brain-derived neurotrophic factor (BDNF)?



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Research on sugar



Sugar on mood and depressive symptoms:

“...complex issue to tease apart the effects of a single nutrient in epidemiological studies since foods represent a mix of macro- and micronutrients. ”

“...difficult to determine if sugar intake was a result of mood disorders as opposed to be the driving factor”

- From Whitehall II study

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Research on sugar



Sugar on hyperactivity from 2020 systematic research review:

“One study reported a **significant relationship between hyperactivity and the consumption frequency of sweet foods** in preadolescent children.

Another study of 7 to 9 years old school-age children found that **high consumption of sugar is associated with increased severity of ADHD in school girls.**

A trial study found mothers of 5- to 7-year-old boys in the **sugar expectancy condition reported their children as significantly more hyperactive.**”

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Research on sugar



Sugar on hyperactivity:

“A meta-analysis and literature review conducted on clinical trials, concluded that **sugar consumption is not a significant risk factor for ADHD symptoms**. This meta-analysis could not find any significant relationship between non-SSB sugar sources and symptoms of ADHD.”

“...dietary sugars alone did not increase the risk of developing ADHD symptoms, nevertheless, higher SSBs (**sugar sweetened beverages**) consumption was associated with a **40% greater odds of ADHD symptoms**”

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Research on sugar



Sugar + fat on ADHD:

Study on longitudinal association over 2 years for children:

“A **sweet dietary pattern** was found to be associated with an increased risk of attention def, hyperactivity, and ADHD symptoms. **Intake of total fat showed a positive correlation** with the prevalence of attention deficit.”

Meta-analysis of 14 observational studies: **diets high in sugar and saturated fat were a risk of attention deficit behaviors.**

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Sugar might NOT be the culprit?



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Ultra-Processed Foods

Foods with industrial formulations composed of refined ingredients, additives and minimal to no whole foods.

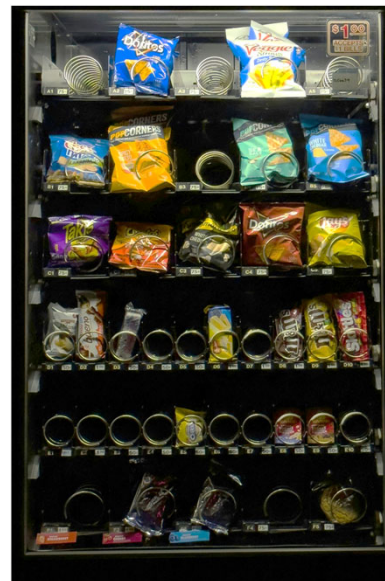


Photo by [Tim Bish](#) on [Unsplash](#)

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Ultra-Processed Foods

UPFs: relatively inexpensive, hyper-palatable, shelf-stable and convenient.

Examples: ice cream, margarines, breakfast cereals, cookies, desserts, yogurts and packaged breads.



Photo by Amazon

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Ultra-Processed Foods

Observational studies have consistently linked high intakes of UPFs with adverse health outcomes.

“UPFs was associated with higher risk of cognitive impairment (hazard ratio [HR] = 1.16, 95% CI 1.09-1.24, $p = 1.01 \times 10^{-5}$) and intake of unprocessed or minimally processed foods with lower risk of cognitive impairment following the MIND diet or Mediterranean diet”

A 2024 umbrella systematic review and meta-analysis found convincing evidence that higher **UPF intake was associated with increased risk of cardiovascular disease related mortality, Type 2 diabetes, as well as anxiety and other combined common mental disorder outcomes.**

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Ultra-Processed Foods

Affects on health **vary based on different subgroups** of UPFs.

Consider:

- Nutrient displacement?
- Satiety regulation?
- UPFs with whole grains and added nutrients?
- Packaging and byproducts?

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What about inadequate intake?



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Calorie Deficit

Calories are king for growing kids.

Macronutrients:

Fat

Protein

Carbs

+ Adequate hydration



Photo by Snickers Mars Co.

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Hunger



Photo by Mentimeter

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Carbohydrates

Complex carbs (whole grains, fruits, vegetables, beans), resistant starch, fermented foods



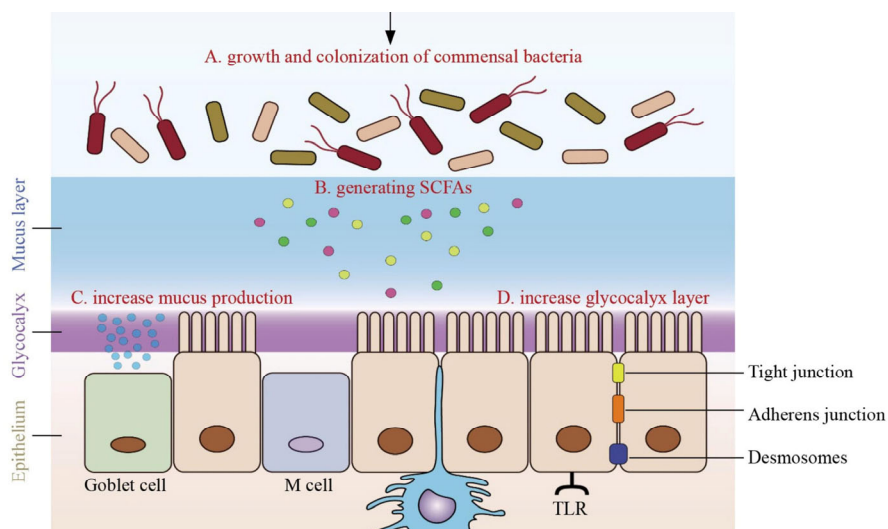
Increase Short Chain Fatty Acids (SCFA)



Photo by Vanessa Loring at pexels

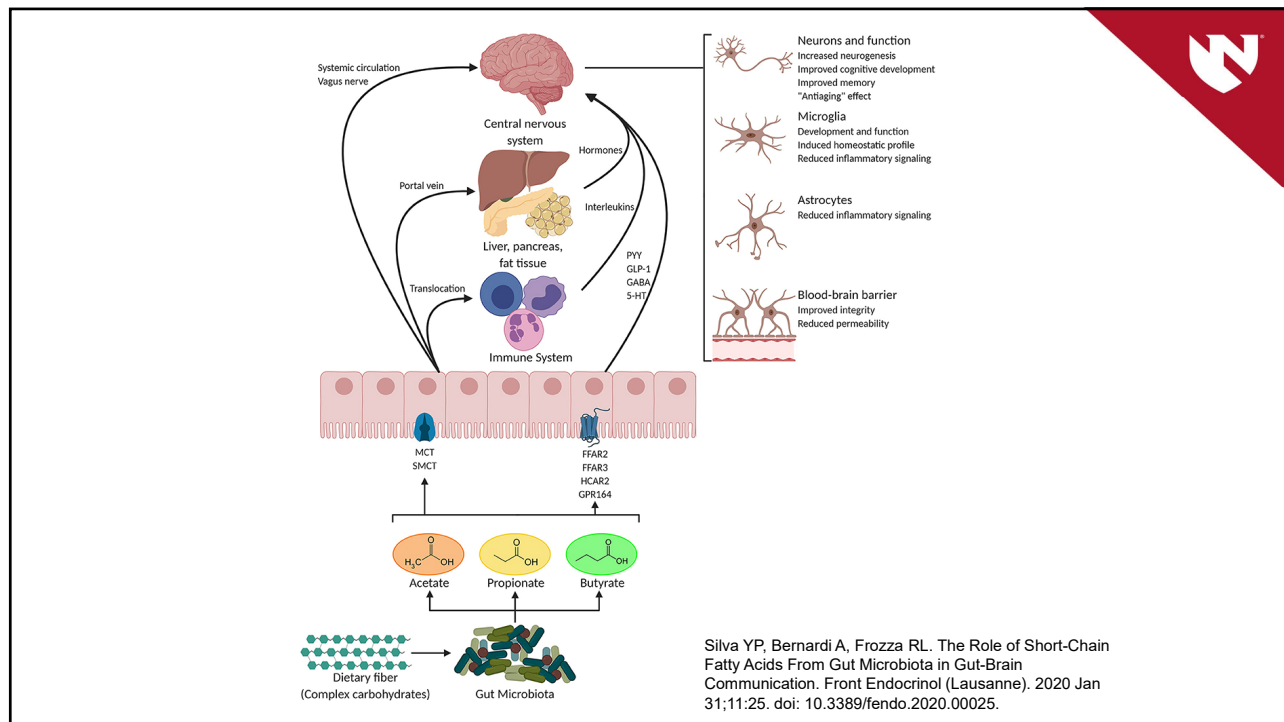
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Short Chain Fatty Acids



Hsu CY, Khachatryan LG, Younis NK, et al. Microbiota-derived short chain fatty acids in pediatric health and diseases: from gut development to neuroprotection. *Front Microbiol.* 2024;15:1456793. doi:10.3389/fmicb.2024.1456793.

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Fats

Deficiencies of polyunsaturated fatty acids have been suggested to play a role in the etiology and therapy of mental disorders.

DHA is a major component of neuronal membranes — it influences membrane fluidity, receptor function, and synaptic signaling.

Emerging studies suggest that diets higher in healthy unsaturated fats (including PUFAs) may improve **bowel regularity**.

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Fats



Low plasma levels of DHA are associated with ADHD in children.

Increasing DHA in children with ADHD: **results are mixed.**

“Although some preliminary clinical research shows that DHA might improve aggression, emotional problems, and social relationships in children with ADHD, taking DHA 345-500 mg daily does not seem to improve objective or subjective measures of ADHD symptoms when compared with placebo.”

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Micronutrients



Magnesium	Calming effect on the nervous system and can help with constipation. Deficiency: hyperactivity, anxiety, sleep disturbances.
Vitamin D	Important in bone health, nervous system, immune system. Deficiency: mood changes, depression, fatigue, muscle weakness, bone pain.
B vitamins	Essential for neurological function. Deficiency: fatigue, weakness, irritability.
Iron	Important in oxygen transit. Deficiency: affects behavioral, speech and cognitive functions, delay wound healing, increase fatigue

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Health Issues from Deficiencies



- Xerophthalmia (vitamin A deficiency)
- Delayed wound healing (zinc and/or iron deficiency)
- Taste changes (zinc deficiency)
- Tooth decay / caries (excess carbohydrate; insufficient fluoride)
- Scurvy (vitamin C deficiency)
- Rickets (calcium and/or vitamin D deficiency)
- Calf tenderness / foot drop (thiamin deficiency)
- Demineralization of the bone (calcium/vit D/phos deficiency; Vit A excess)
- Peripheral neuropathy (Vitamin B deficiency; Vit B6 toxicity)

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Case study



Adam: 6-year-old boy with ADHD, autism, pica.

Parents report he has a strong drive to eat leaves, sand, dirt.

High lead levels. Very limited diet, mostly crunchy or soft processed foods.

RDN worked with behavioral therapist on supplement acceptance. Focused on increasing iron, zinc and vitamin C.

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Case study

After intervention, lead levels decreased significantly. Parents and ABA daycare reports almost zero attempts at ingesting inedible items. ABA therapists noticed improvement in attention and cognitive tasks.

	Date	Lead (<3.4)	Ferritin (10-60)	HGB (11.5-13.5)	Iron (45-160)
Start of intervention	11/14/23	6.6	5.7	11.1	63
3/14/24 →	2/28/24	5.2	5.0	11.1	63
Improvement of Pica	8/27/24	4.5	8.2	12.1	130
symptoms →	4/15/25	2.9		11.5	

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Diet Variety

A well-balanced diet with a wide variety of foods, especially whole foods and high fiber foods, nourishes a healthy gut microbiome.



Photo by cottonbro studio at pexels

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Diet Quality

Controlled trial 80 children

Significantly improved:

- Hyperactivity
- Emotional symptoms
- Conduct problems at school
- Peer relationship problems
- Prosocial behaviors

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Diet Quality

Followed a diet close to the DASH & MIND diets:

- ❖ High amounts of fruits and vegetables
- ❖ Low fat dairy products
- ❖ Vitamin C / magnesium / PUFAs / zinc
- ❖ Reduced simple sugars, processed meats, animal & hydrogenated fats



Photo by <https://nutritionsource.hsph.harvard.edu/healthy-weight/diet-reviews/mind-diet/>

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Diet elimination

Eliminate majority of food items from the diet and reintroduce foods one at a time

Purpose to identify food triggers of ADHD symptoms or food sensitivities

Promising results but must be done by trained medical professionals. Parents and children must be dedicated

Assure a robust acceptance of variety of foods before eliminating foods

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Case Study - Sam



“Sam” 3-year-old male

Dx: Autism

BMI: 50th percentile

- **Diet:** Drinks almond milk and water, eats almond yogurt, poppable chips.
- **Diet modifications:** Parents started a gluten free diet and avoid soy, broccoli, pea, pork, and dairy based on a blood sensitivity test.
- Parents also avoid coconut since Sam has shown discomfort after consuming coconut.

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Case Study - Sam



- Sam used to eat chicken nuggets and pancakes but stopped when switched to gluten free products
- Sam will snack on poppable chips throughout the day – daily calorie needs likely met.

Protein 54%

Thiamin 65%

Riboflavin 48%

VitB12 12%

Folate 53%

Iron 50%

Phosphorus 53%

Potassium 91%

Zinc 52%

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Case Study - Sam



Parents report variable bowel movements – ranging from straining, hard stools to very loose stools.

Sam's constipation issues and stomach pain led to parents looking at food intolerances.

GI physician would not write an order for a dairy free/soy free meal supplement.

Parents struggled to find a multivitamin he would take that met their requirements.

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Case Study - Sam



Approach:

Need for intensive daily treatment.

Rule out any oral motor difficulties.

Expand on foods parents are comfortable with first and are covered by WIC.

Track bowel movements.

Introduced gluten foods and dairy. Noted some loose stools with milk beverage – all other dairy was fine. Started soy milk.

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Case Study - Sam



After intensive treatment:

- Over 20 foods accepted: 6 veggies, 5 fruit, 4 grains, 5 proteins/entrees. Also consuming soy milk and yogurt to meet calcium needs. Still avoiding coconut.
- All macro and micronutrients met.
- Dad continued tracking bowel movements after treatment. Reported consistent daily soft formed BMs. No stomach pains.

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Case Study - Sam



After intensive treatment:

Sam back at his ABA day program. Data shows improvement in various tracked behaviors.

BCBA noted:

"[Sam] is overall so much happier! Just his demeanor is so much better and I really feel like he feels better since his diet changed"

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Eating behaviors



Eating Behavior	Background
Impulsive eating	Eating quickly -- Choosing packaged UPF snacks – Hungry -- Medications
Selective eating	Rigidity around new foods -- Choosing only safe foods – New foods cause anxiety or difficulties – Highly prefer consistency and predictability
Distracted eating	Overeating -- slow eating -- missing hunger/fullness cues
Emotional eating	Using food to cope with boredom, procrastination, stress, frustration -- Food provides a sensory or dopamine boost
Irregular eating	Forgetting to eat, skipping meals -- Difficulty with executive functioning – In a thought/behavior loop. – Fixated on an interest – Eating is difficult -- Medications

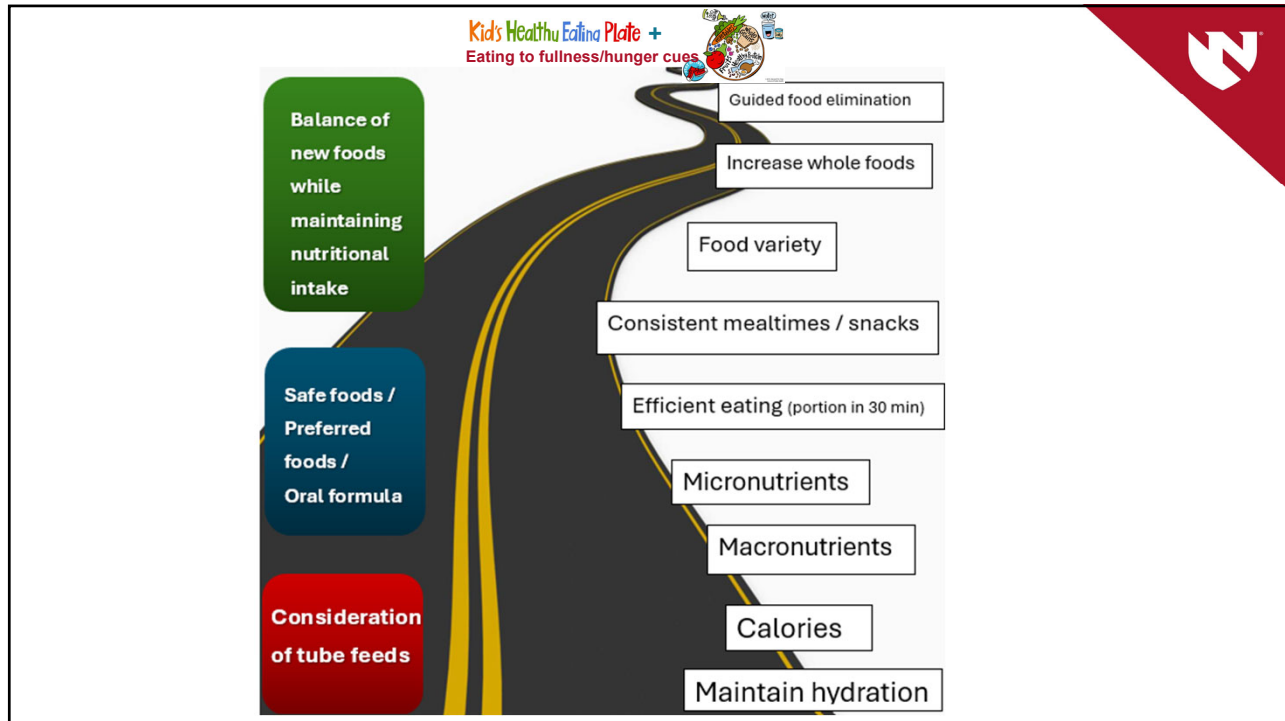
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Mealtime Behaviors



Mealtime Behavior	Background
Challenges with starting a meal	- New environment? - Difficulty set shifting
Getting up frequently	- Sensory – Hyperactivity
Taking a long time to eat	- Distractions -- Dyspraxia – Oral motor issues - Fatigue
Needing specific silverware, plates, bowls etc	- Sensory specific – Rigidity with consistency – Special equipment for skills
Keeping food separate	- Visually needs to have items separated to make sense – Mixing foods can ruin a preferred food
Gagging / emesis	- Sensory – Immature oral motor sensitivity – untreated GI disorder -- Gastroparesis

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Why do we eat?

- Health
- Medicine
- Hunger
- Pleasure
- Social
- Caregiving

Everyday foods

Celebratory foods

Photos by mk.s and Imad 786 and Heather Ford and Isabella Fischer and Vyshnavi Bisani and Edward Franklin on Upstash

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Individualize Approach – Dietitian role

- Full nutrition assessment
- Assure adequate weight/height growth
- Prioritize nutrition gaps:
 1. Macronutrients and calories
 2. Address constipation issues
 3. Balance Iron and Calcium
 4. Variety
 5. Address any other micronutrient imbalance

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What is your dietitian thinking about?

The infographic lists the following factors:

- AGE AND GENDER
- BODY IMAGE
- ACTIVITY LEVEL
- WORK PATTERN
- FOOD/NUTRIENTS
- EXISTING MEDICATION
- FAMILY & LIFESTYLE
- ABILITY
- CULTURE
- RELIGION & BELIEFS
- YOUR BODY SIZE
- TASTE & EATING HABITS
- SYMPTOMS & CONDITIONS
- YOUR ENVIRONMENT
- COOKING SKILLS
- YOUR MENTAL WELLBEING

Photo by Hoys Allied Health and Wellness

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Individualize Approach – Supportive role

- Help family plan schedule for meals and snacks
- Work with a behavioral therapist to address any behaviors that significantly impact health meal schedules
- Find palatable recipes using foods the family eats as a guide
 - Can use fat and sugar to increase less preferred foods!
 - Eventually start to fade those support foods out.

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Personalized Plan - example

Chicken nuggets – 3 each	Avocado – 2 oz	Any fruit, berries etc – ¼ cup
Mac and cheese – ½ cup	Broccoli and cheese – ¼ cup	Applesauce – ¼ cup
Refried beans – ½ cup	Egg, rice, (beans and carrots) – ¼ cup	Apple sauce + prunes – ¼ cup
Cottage cheese – ½ cup	Cucumbers – 5 slices	
Meatloaf – 1 slice	Apple sauce – ¼ cup	
Grilled chicken bites – 2 oz	Spinach rice bowl – ½ cup	
Meatballs – 3 small		
Egg – 1 egg patty		

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General Recommendations



- Ultimate goal is increasing variety of whole foods, NOT perfection.
- Wait to start an elimination or restricted diet after all nutrient needs are met.
- Help families reduce the amount of UPFs and artificially dyed foods without significantly impacting the child's nutrient intake.
- Help families with meal/snack schedules and foods for variety. Need help getting out of a rut!

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Guidelines for MIND diet



Green leafy vegetables

How much: 6+ servings a week

Serving size: 1 cup raw or ½ cup cooked

Examples: Spinach, kale, collards, mustard greens and arugula

Other vegetables

How much: 1+ serving each day

Serving size: ½ cup

Examples: Asparagus, broccoli, Brussels sprouts, carrots, cauliflower, green beans, mushrooms, onions, snow peas, squash, bell peppers, sweet potatoes and tomatoes

Nuts

How much: 5+ servings a week

Serving size: 1 ounce

Examples: Almonds, cashews, hazelnuts, Brazil nuts, macadamia nuts, peanuts, pecan halves and walnut halves

Berries

How much: 2+ servings a week

Serving size: ½ cup

Examples: Blackberries, blueberries, raspberries and strawberries

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Beans and legumes**How much:** 3+ servings a week**Serving size:** ½ cup**Examples:** Black beans, pinto beans, cannellini beans, garbanzo beans, kidney beans, red beans, white beans and edamame**Whole grains****How much:** 3+ servings a day**Serving size:** ½ cup or 1 slice**Examples:** Whole grain bread, brown rice, wild rice, whole grain pasta, quinoa, barley, bulgur, farro, oats and whole grain cereal**Fish****How much:** 1+ serving a week**Serving size:** 3 to 5 ounces**Examples:** Salmon, tilapia, cod, halibut, mahi-mahi, canned tuna**Poultry****How much:** 2+ servings a week**Serving size:** 3 to 5 ounces**Examples:** Skinless chicken breast and skinless turkey breast**Extra virgin olive oil****How much:** 2 servings a day**Serving size:** 1 tablespoon**Examples:** Extra virgin olive oil, can be used in salad dressings, sauteing, dip for bread or roasting vegetables

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Example: Child Guidelines



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Tips and Tricks:

- ❖ Start small with achievable goals.
- ❖ Use preferred flavors to help with palatability ([maple glazed salmon](#)).
- ❖ Give small amounts of target food.
- ❖ Shred up small (think [chopped kale salad](#) or [spinach balls](#)) or puree into a dip ([muhammara](#)).
- ❖ REPEAT the foods even if no one likes it at first.
- ❖ Have kids be a part of the goals!

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When to refer to specialists:

- Gastroenterologist:
 - Bowel issues or regular emesis impacting food desire or ADLs
 - Low calorie or macronutrient intake affecting growth; underweight
 - R/o gastrointestinal issues
- Pediatric Dietitian:
 - Child eats less than 20 foods
 - Weight or growth concerns; nutrient deficiencies
 - Needing clear guidance on mealtimes or recipes or textures
 - If parents need help prioritizing family food goals or dietary recommendations

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When to refer to specialists:

- Occupational Therapist:
 - Sensory issues that may impact foods or ability to sit for meals
 - Fine motor issues that can impact self feeding
- Speech Therapist (feeding):
 - Oral feeding or drinking difficulties
 - Dysphagia
 - R/o causes of prolonged chewing, packing, gagging or inefficient intake during meals

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When to refer to specialists:

- Behavioral Therapists:
 - Behavioral issues surrounding mealtime or staying at the table at mealtimes
 - Behavioral issues with limit setting, schedules with foods and snacks
 - Impulse control, rigidity, or using food as a coping strategy
- Multidisciplinary Feeding Team:
 - 20 or less foods with a behavioral component that is affecting their health or food intake
 - Uncertain cause of feeding struggles or numerous causes of feeding struggles

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Interactive Case Studies



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