Nutrigenomics in Clinical Practice: Genes, Food, and Specialty Diagnostics

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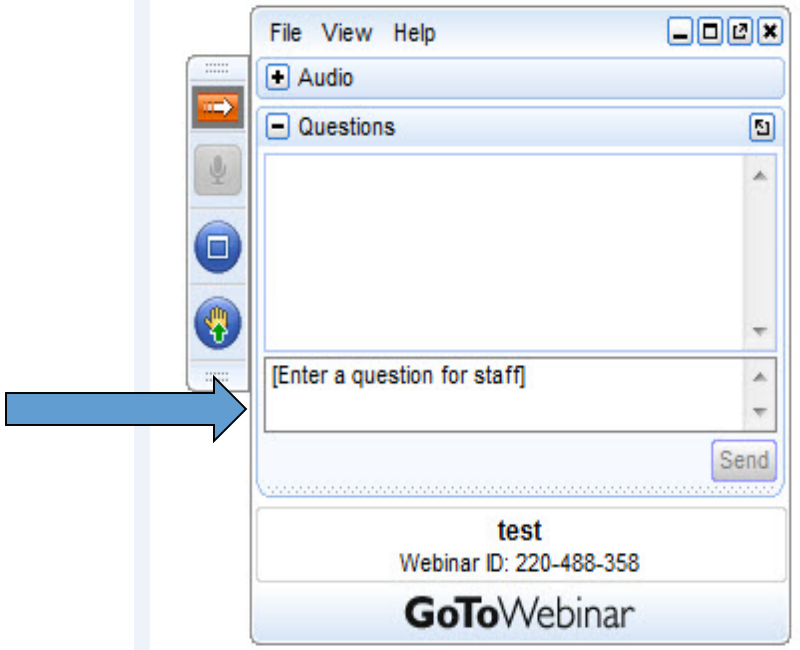
Technical Issues & Clinical Questions

Please type any technical issue or clinical question into either the “Chat” or “Questions” boxes, making sure to send them to “Organizer” at any time during the webinar.

We will be compiling your clinical questions and answering as many as we can the final 15 minutes of the webinar.



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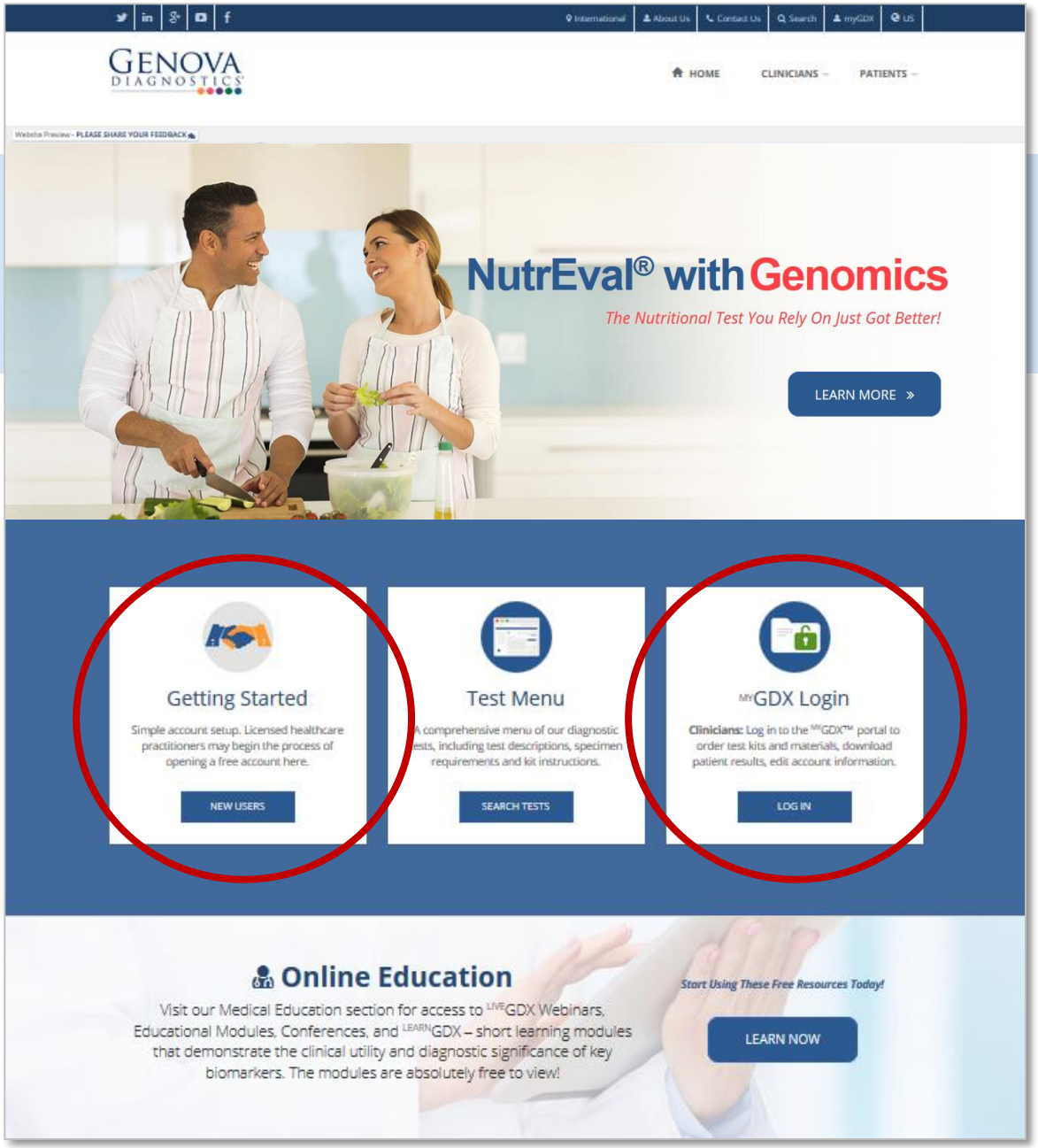
DISCLAIMER: *Please note that any and all emails provided may be used for follow up correspondence and/or for further communication.*

Need More Resources?

Ensure you have an account!



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Objectives

- To have a general understanding of nutrigenomics
- To learn how to combine the basics of genetics + nutrition
- To see how nutrigenomics can be applied through various examples
- To learn about specific SNPs for the Genova platform

Food Is…

- Medicine
- Connection
- *Information*

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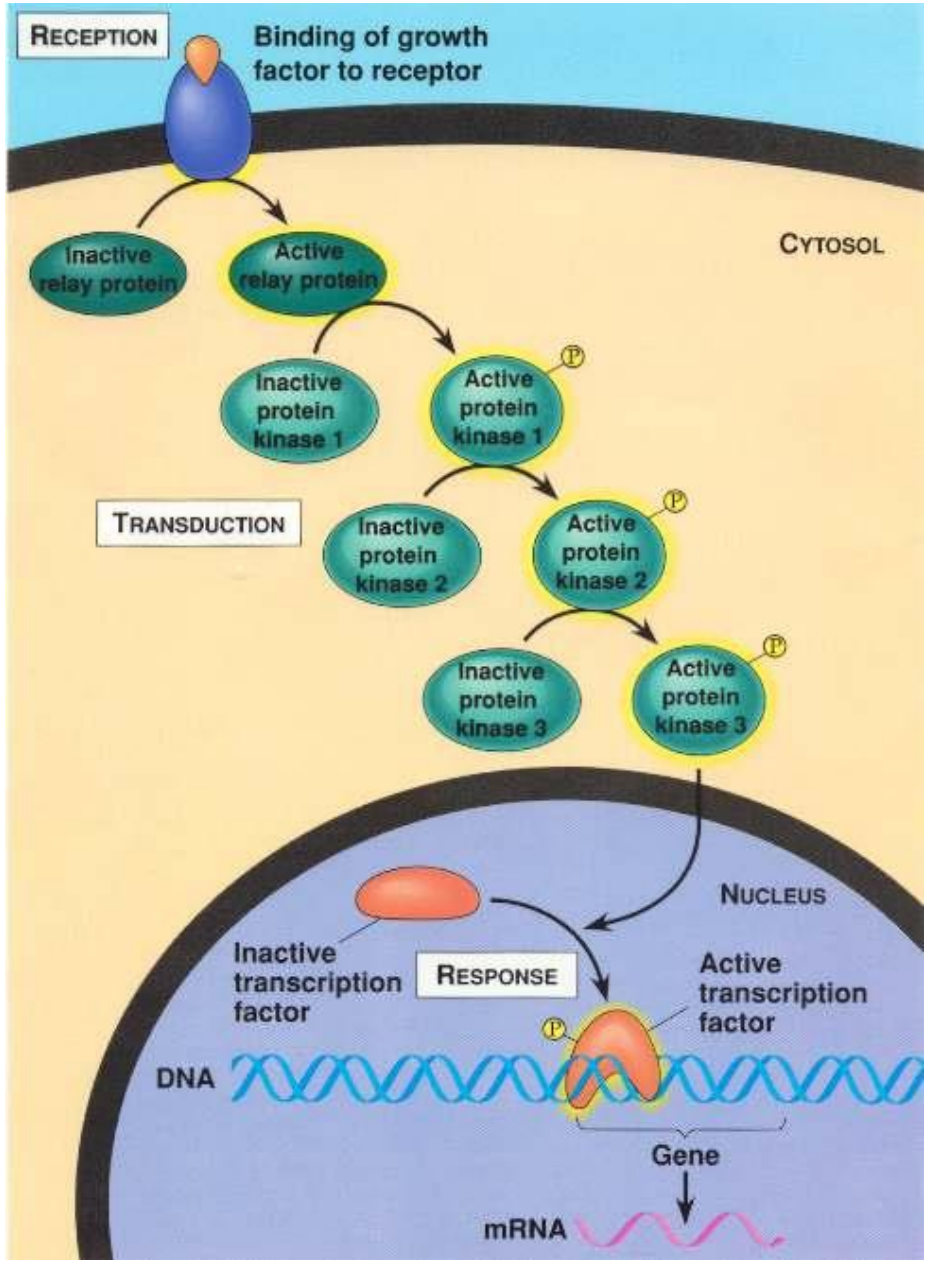
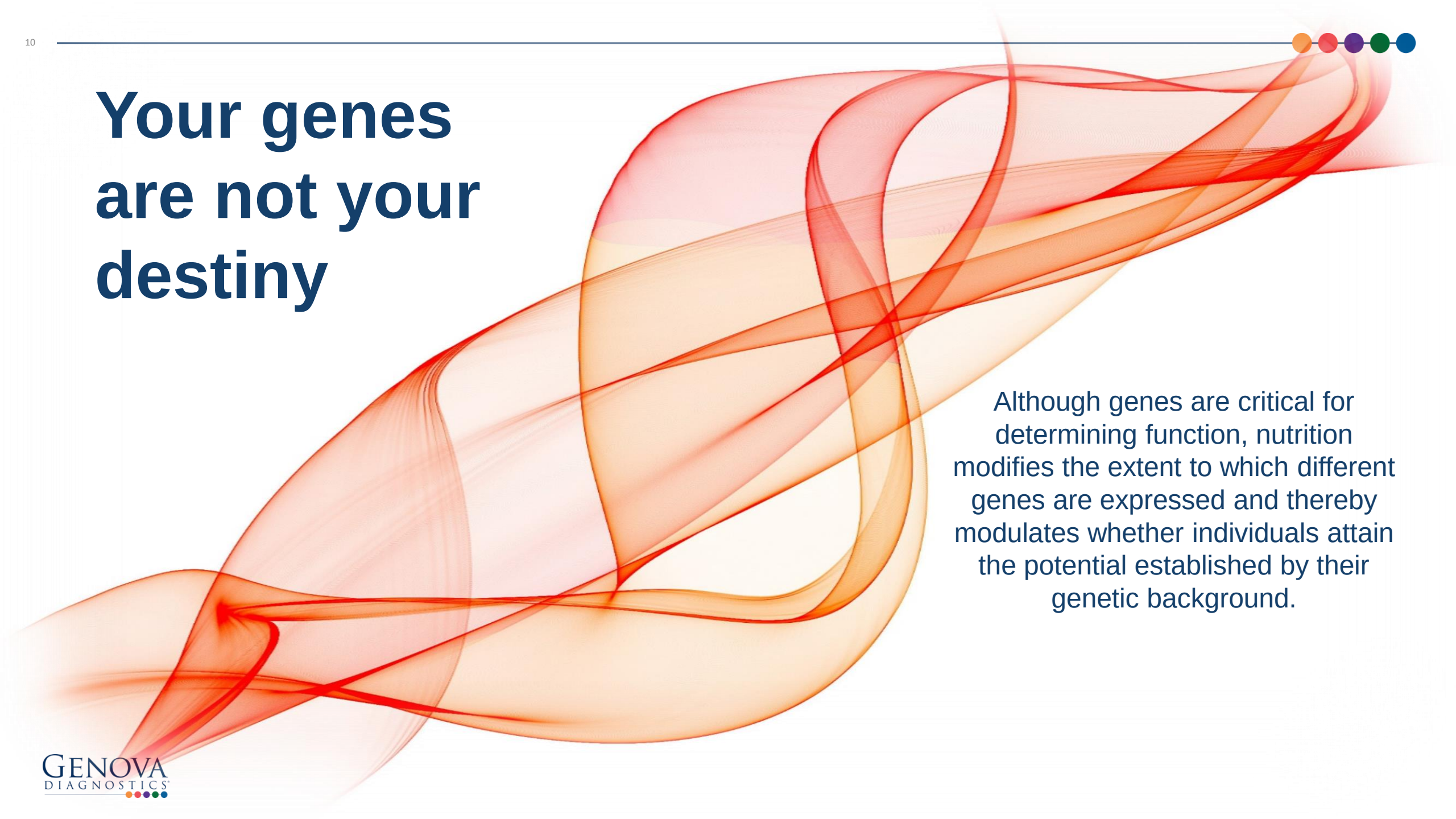
Nutrition in Clinical Practice 20:75-87, February 2005

Food sends informational signals to the genes



http://www.uic.edu/classes/bios/bios100/mike/spring2003/lect07.htm

Your genes are not your destiny



Although genes are critical for determining function, nutrition modifies the extent to which different genes are expressed and thereby modulates whether individuals attain the potential established by their genetic background.

Personalized Nutrition (Healthcare)

Targeted dietary prescriptions for the individual based on genetics and lifestyle

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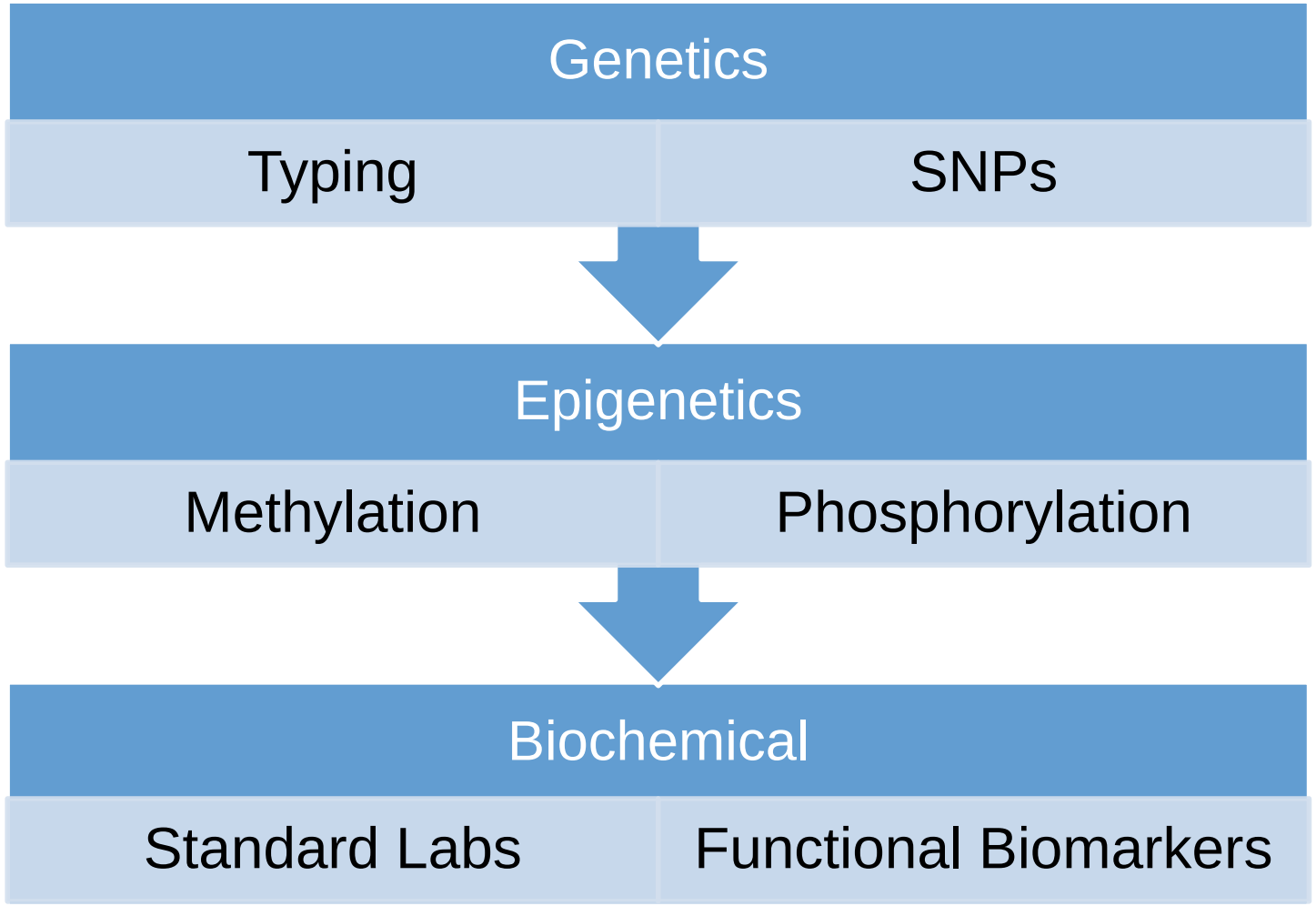
Levels of personalized, functional medicine-based health



Nutrition Journal

BioMed Central

Research

Open Access

Improved weight management using genetic information to personalize a calorie controlled diet

Ioannis Arkadianos[1], Ana M Valdes[2], Efstathios Marinos[3], Anna Florou[1], Rosalynn D Gill[4] and Keith A Grimaldi*[4]

Address: [1]The Dr Arkadianos Clinic, Messogion Av, Athens, Greece, [2]Twin Research Unit, King's College London, UK, [3]Biomedical Engineering Laboratory, National Technical University of Athens, Greece and [4]Sciona Inc, Boulder, 80302, Colorado, USA

Email: Ioannis Arkadianos - idc.diet@eexi.gr; Ana M Valdes - ana.valdes@kcl.ac.uk; Efstathios Marinos - smarin@biomed.ntua.gr; Anna Florou - tsurekia@gmail.com; Rosalynn D Gill - rgill-garrison@sciona.com; Keith A Grimaldi* - kgrimaldi@sciona.com

* Corresponding author

- Can including genetic information to personalize a patient's diet (nutrigenetics) improve long-term weight management?
- N=50 patients in genetic group; N=43 patients in control group
- Standard Mediterranean diet, modified for nutrigenetic group

Gene	Gene symbol
Angiotensin I converting enzyme	*ACE*
Apolipoprotein C-III	*APOC3*
Cystathionine-beta-synthase	*CBS*
Cholesteryl ester transfer protein	*CETP*
Collagen, type I, alpha 1	*COL1A1*
Glutathione S-transferase M1	*GSTM1*
Glutathione S-transferase pi	*GSTP1*
Glutathione S-transferase theta 1	*GSTT1*
Interleukin 6	*IL6*
Lipoprotein lipase	*LPL*
5-methyltetrahydrofolate-homocysteine methyltransferase reductase	*MTRR*
5,10-methylenetetrahydrofolate reductase	*MTHFR*
5-methyltetrahydrofolate-homocysteine methyltransferase	*MTR*
Nitric oxide synthase 3 (endothelial cell)	*NOS3*
Peroxisome proliferator-activated receptor gamma	*PPARG*
Superoxide dismutase 2, mitochondrial	*SOD2*
Superoxide dismutase 3, extracellular	*SOD3*
Tumor necrosis factor	*TNFα*
Vitamin D receptor	*VDR*

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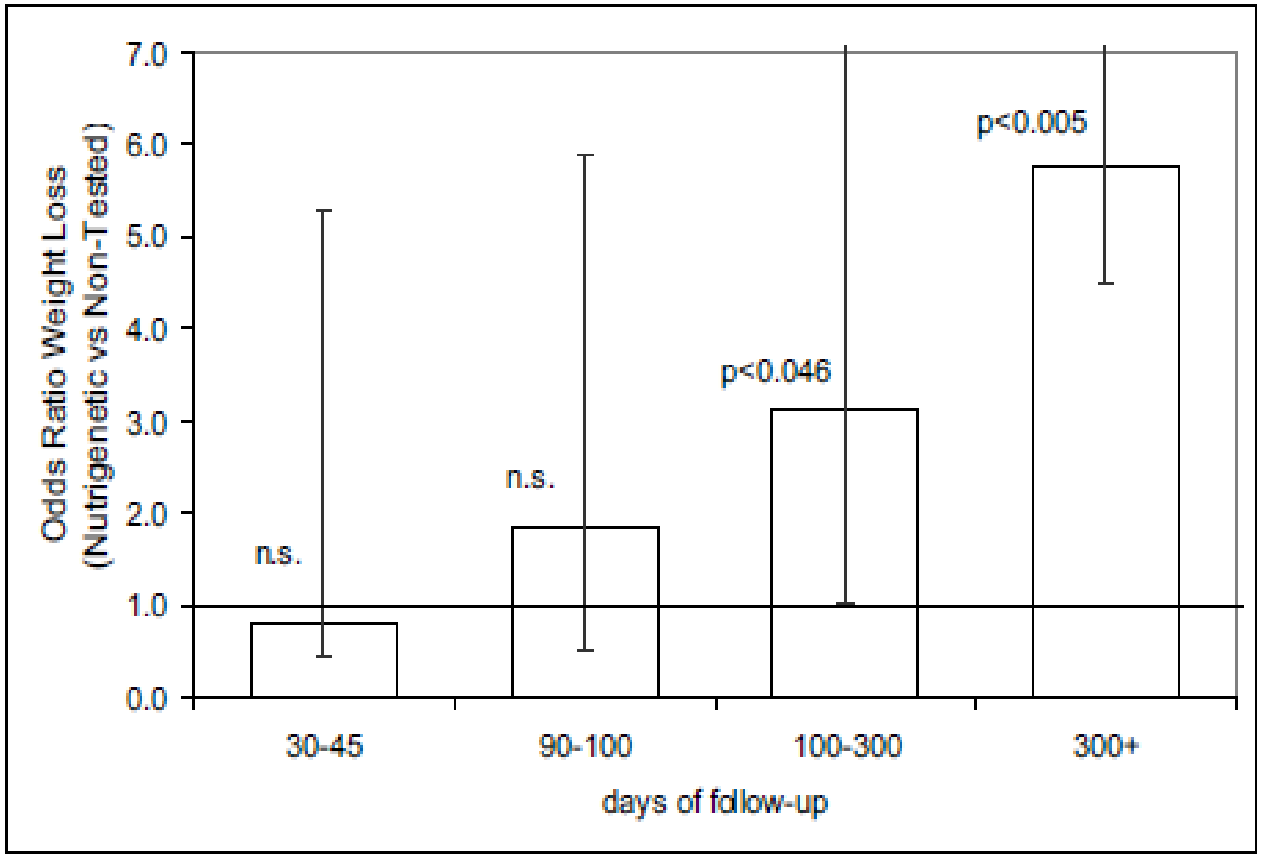
Nutrition Journal 2007, **6**:29 doi:10.1186/1475-2891-6-29



After 300 days of follow-up individuals in the nutrigenetic group were more likely to have maintained some weight loss (73%) than those in the comparison group (32%).

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Nutrition Journal 2007, 6:29 doi:10.1186/1475-2891-6-29

Personalized Nutrition

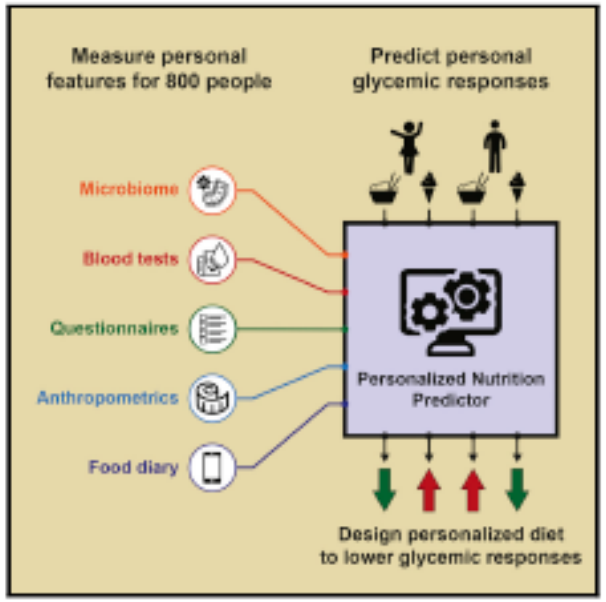
Here, we continuously monitored week-long glucose levels in an 800-person cohort, measured responses to 46,898 meals, and found high variability in the response to identical meals, suggesting that universal dietary recommendations may have limited utility.

Article

Cell

Personalized Nutrition by Prediction of Glycemic Responses

Graphical Abstract



Authors

David Zeevi, Tal Korem, Niv Zmora, ..., Zamir Halpern, Eran Elinav, Eran Segal

Correspondence

eran.elinav@weizmann.ac.il (E.E.), eran.segal@weizmann.ac.il (E.S.)

In Brief

People eating identical meals present high variability in post-meal blood glucose response. Personalized diets created with the help of an accurate predictor of blood glucose response that integrates parameters such as dietary habits, physical activity, and gut microbiota may successfully lower post-meal blood glucose and its long-term metabolic consequences.

Highlights

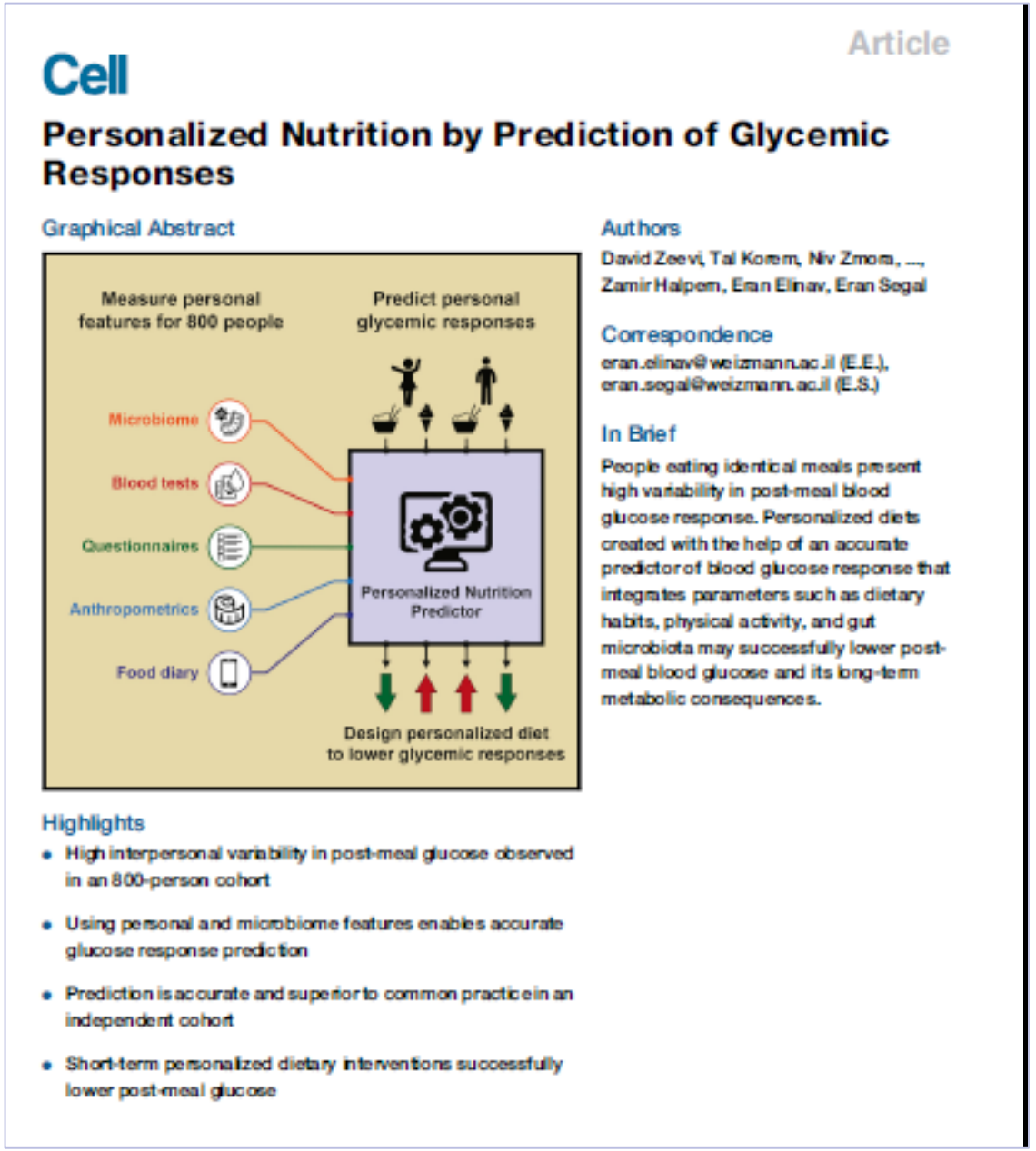
- High interpersonal variability in post-meal glucose observed in an 800-person cohort
- Using personal and microbiome features enables accurate glucose response prediction
- Prediction is accurate and superior to common practice in an independent cohort
- Short-term personalized dietary interventions successfully lower post-meal glucose

GENOVA DIAGNOSTICS

Cell. 2015 Nov 19;163(5):1079-94. doi: 10.1016/j.cell.2015.11.001.

Personalized Nutrition

We devised a machine-learning algorithm that integrates blood parameters, **dietary habits, anthropometrics, physical activity, and gut microbiota** measured in this cohort and showed that it accurately predicts personalized postprandial glycemic response to real-life meals.



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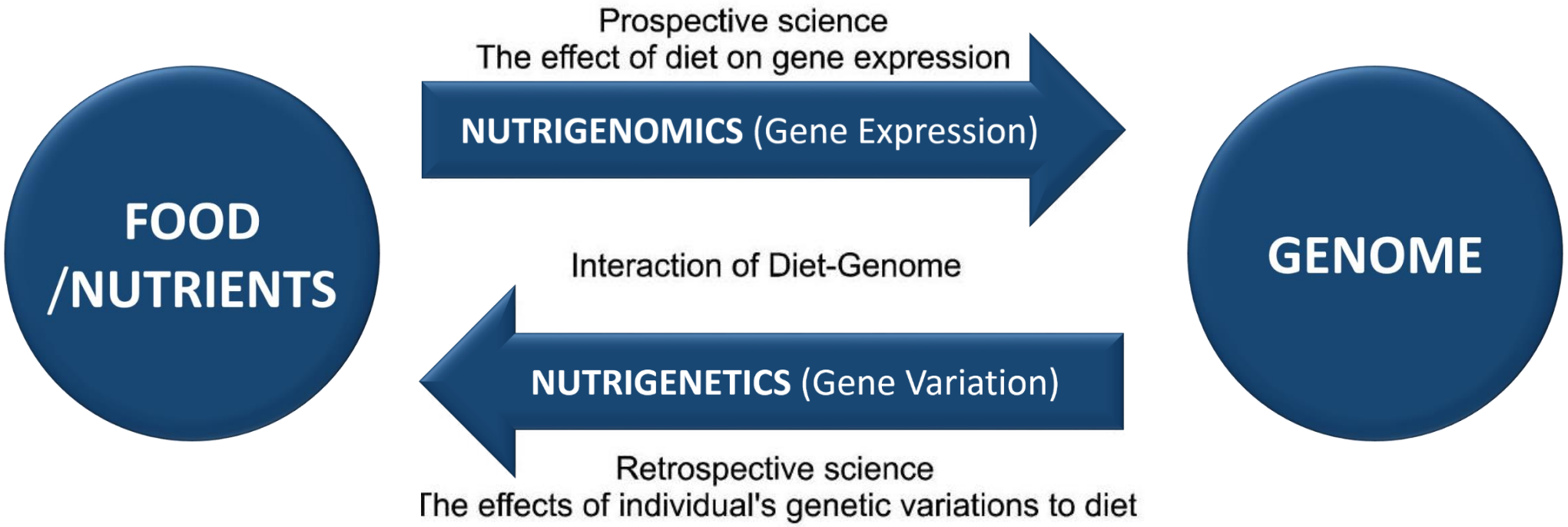
Nutrigenomics: The Overview



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Prev Nutr Food Sci. 2015 Mar; 20(1): 1–7.

Nutrigenomics

- The influence of food on genetic expression
- How what you eat turns on or off your genes
- Refers to the interaction between genes and nutrients
- Modification can occur directly or indirectly
- Chronic disease onset, incidence, progression, and/or severity influenced by diet-regulated genes and their common variants

Nutrition in Clinical Practice 20:75-87, February 2005

Nutrigenomics

- Examples:
  - Sulforaphane in broccoli can turn off oncogenes (cancer-initiating or –causing genes)
  - Resveratrol in grape skin can lead to changes in gene expression that cause a shift in energy production and metabolism

Nutrition in Clinical Practice 20:75-87, February 2005

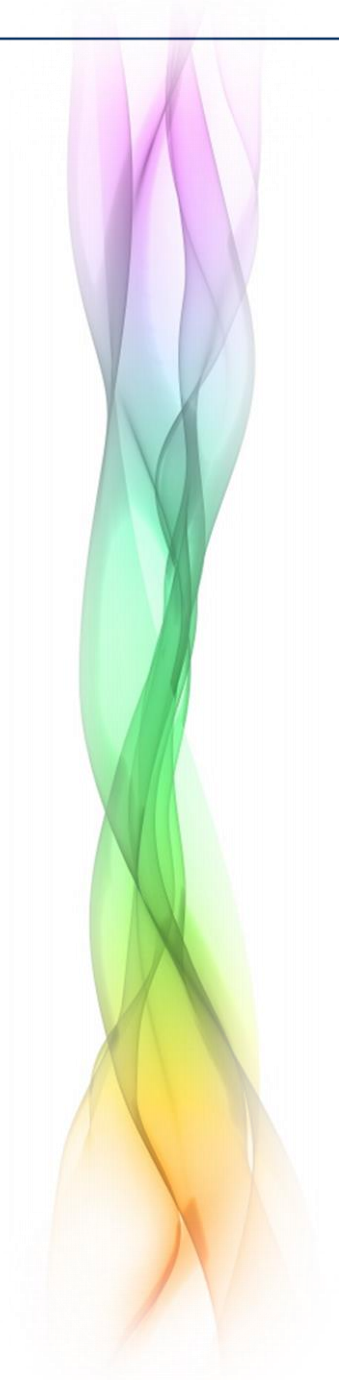
Why is nutrigenomics important for nutrition?

It allows us to question current dogma

- Food is more than calories
- A calorie is a calorie
- Bad foods give you disease unless you have genes to intervene and protect you

New concepts to ‘digest’

- Food is full of informational signals
- A calorie is to be judged upon the context it comes from
- We are continually interacting with dietary signals, in which certain foods enhance a beneficial, neutral or negative effect on genes
- Clinical trials need to include genetic variability in SNPs as a factor



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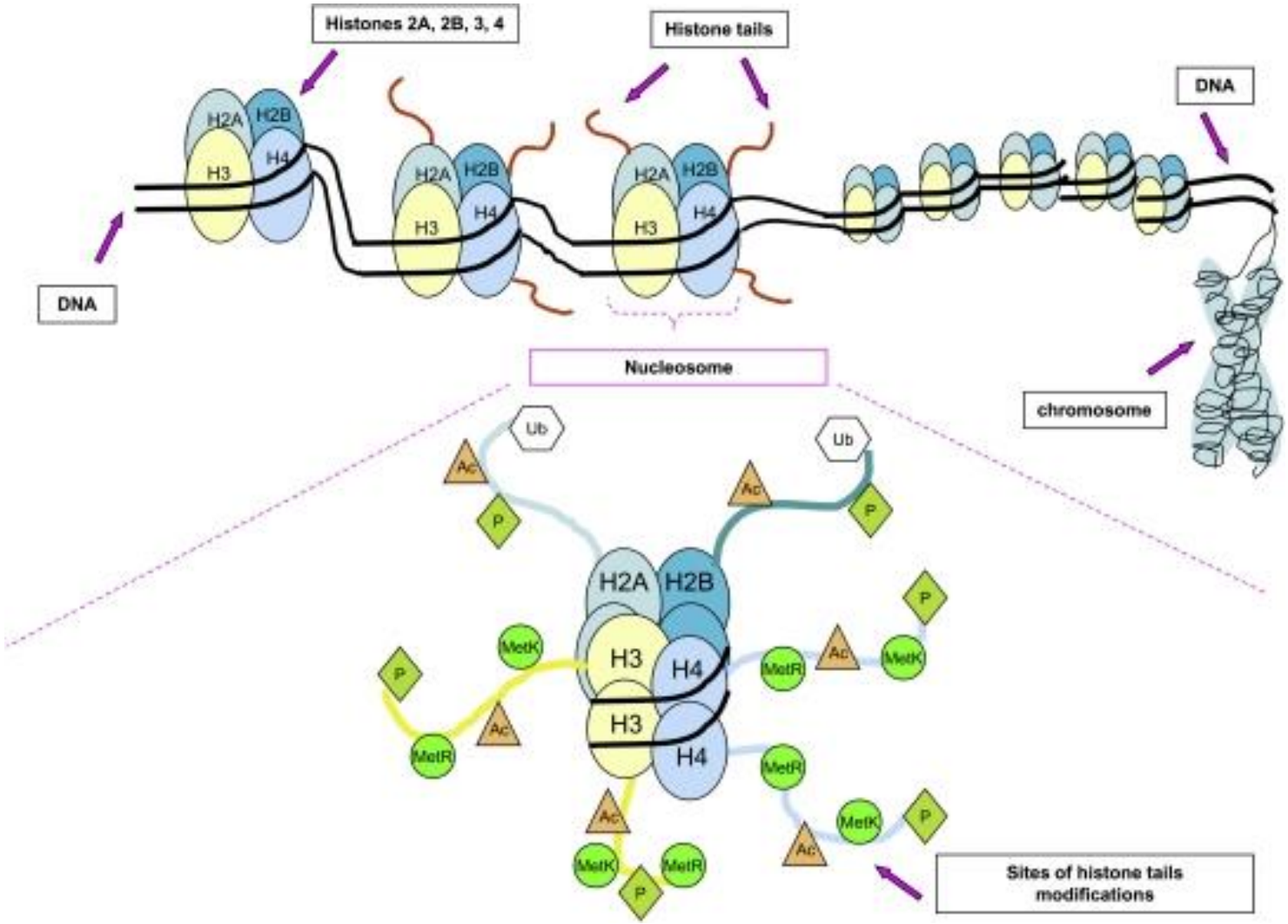
Nutrigenetics

- The genetic makeup a person has that leads them to require certain nutrients or higher/lower levels of nutrients, both of which may be implicated in their propensity towards disease
- Includes SNPs
- A field of study that will play a role in personalized nutrition

Epigenetics: The Wild Card

- Heritable changes that do not impact gene sequence.
- Modification to gene sites or histone proteins
  - Methylation
  - Phosphorylation
  - Acetylation
  - Ubiquinylation



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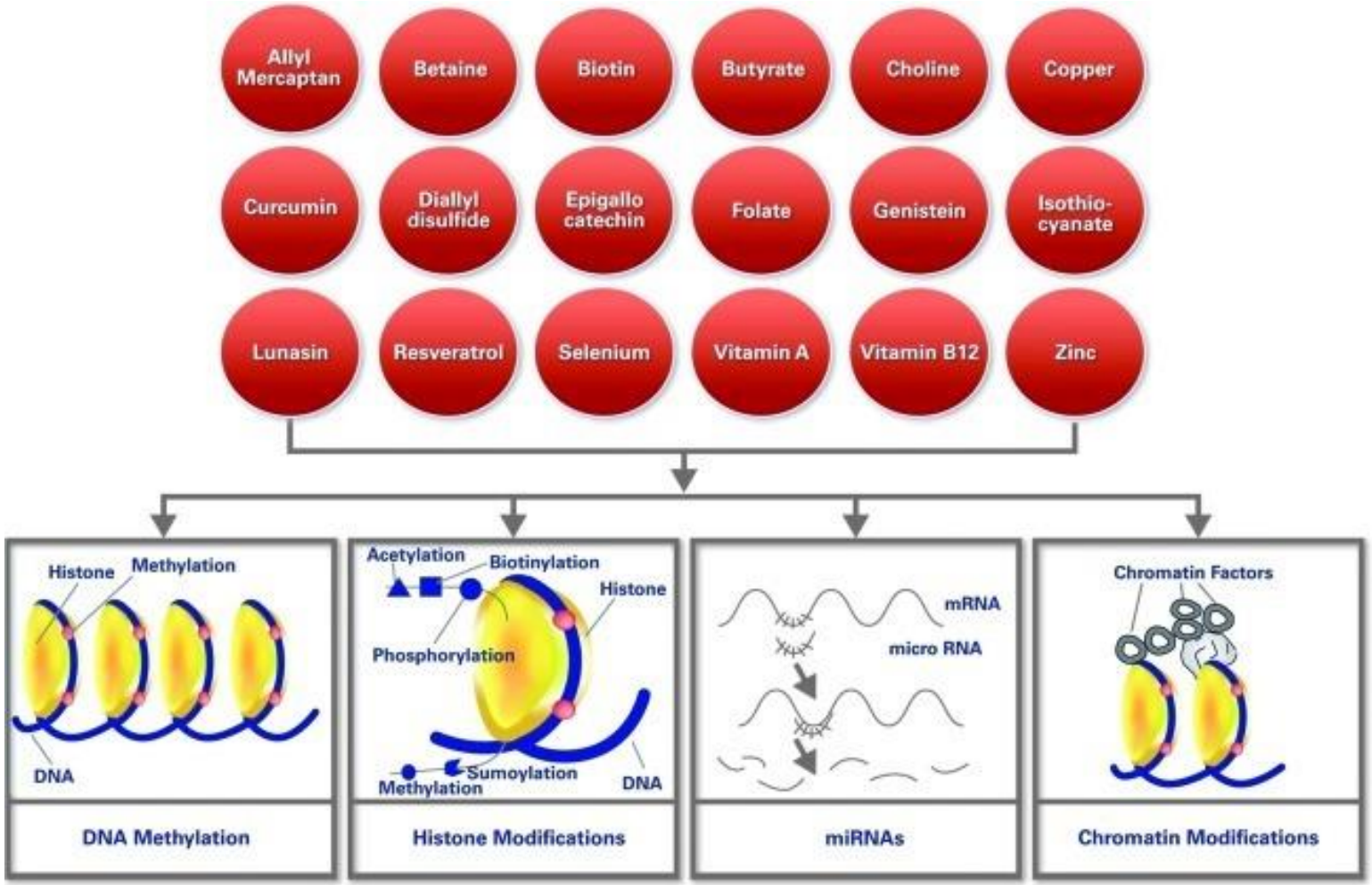
Nutrition in Clinical Practice 20:75-87, February 2005

Nutrients play a role in epigenetics



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Antioxid Redox Signal. Jul 15, 2012; 17(2): 355–364.

Foodomics

Foodomics is the comprehensive, high-throughput approach for the exploitation of food science in the light of an improvement of human nutrition

Foodomics is a new approach to food and nutrition that studies the food domain as a whole with the nutrition domain to reach the main objective, the optimization of human health and well-being

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Genes Nutr. 2013 Jan;8(1):1-4. doi: 10.1007/s12263-012-0310-x. Epub 2012 Aug 30.

Phytoprofiling

The role of phytochemical modulation of cellular physiology and propose phytochemical profiling, or phytoprofiling, to assist in the facilitation of determining phytonutrient requirements with more effective interventions with plant-derived compounds

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J Proteome Res. 2013 Mar 4. [Epub ahead of print]
Toward Personalized Nutrition: Comprehensive Phytoprofiling and Metabotyping. Xie G, Li X, Li H, Jia W

Nutrition & SNPs: Specific Profiles

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Here's the problem:

Nutrient insufficiency

+ Enzyme insufficiency

= Poor methylation capacity

What You Need to Know

SNPs are cutting-edge markers that provide general information about a patient's propensity toward disease

SNPs may provide insight into an array of patient conditions such as depression, anxiety, cardiovascular disease, cardio-metabolic syndrome, inflammatory conditions, and chronic pain syndromes

What You Need to Know

SNPs are an important tool for personalized nutrition

Nutrition needs to be personalized for it to be effective long-term. Diagnostic labs that assess genetic information, as well as functional biomarkers, can be utilized for this purpose

What You Need to Know

For best results, couple SNPs with other diagnostic and functional biomarkers

Having a variety of tests, such as NutrEval, together with SNPs, supports broadened clinical insight and enhanced personalization of therapeutics

What You Need to Know

Don’t diagnose or prescribe based on a single SNP

SNPs are good information for a clinician to have about a patient, and are to be seen as part of a complete picture rather than used in isolation to make a diagnosis or to prescribe treatment

What You Need to Know

Your patients' SNPs are not "their destiny"

Many people mistakenly assume that the presence of a certain gene means they are destined to experience the associated disease. However, only a few very rare diseases (such as Huntington or Tay-Sachs diseases) are certainties determined by genetic makeup.

Most genes have flexible expressions and researchers have found that complex interactions among multiple genes plus the environment are fundamentals of disease etiology

What You Need to Know

The same SNP may not look the same in everyone

SNPs may be differentially expressed based on one's nutrient status, interacting SNPs, stressors, environment, and lifestyle choices

What You Need to Know

SNPs may express differently in different population groups

Literature used to assess SNPs may be quite varied in findings, and be different depending on population groups, including ethnicity and gender variables

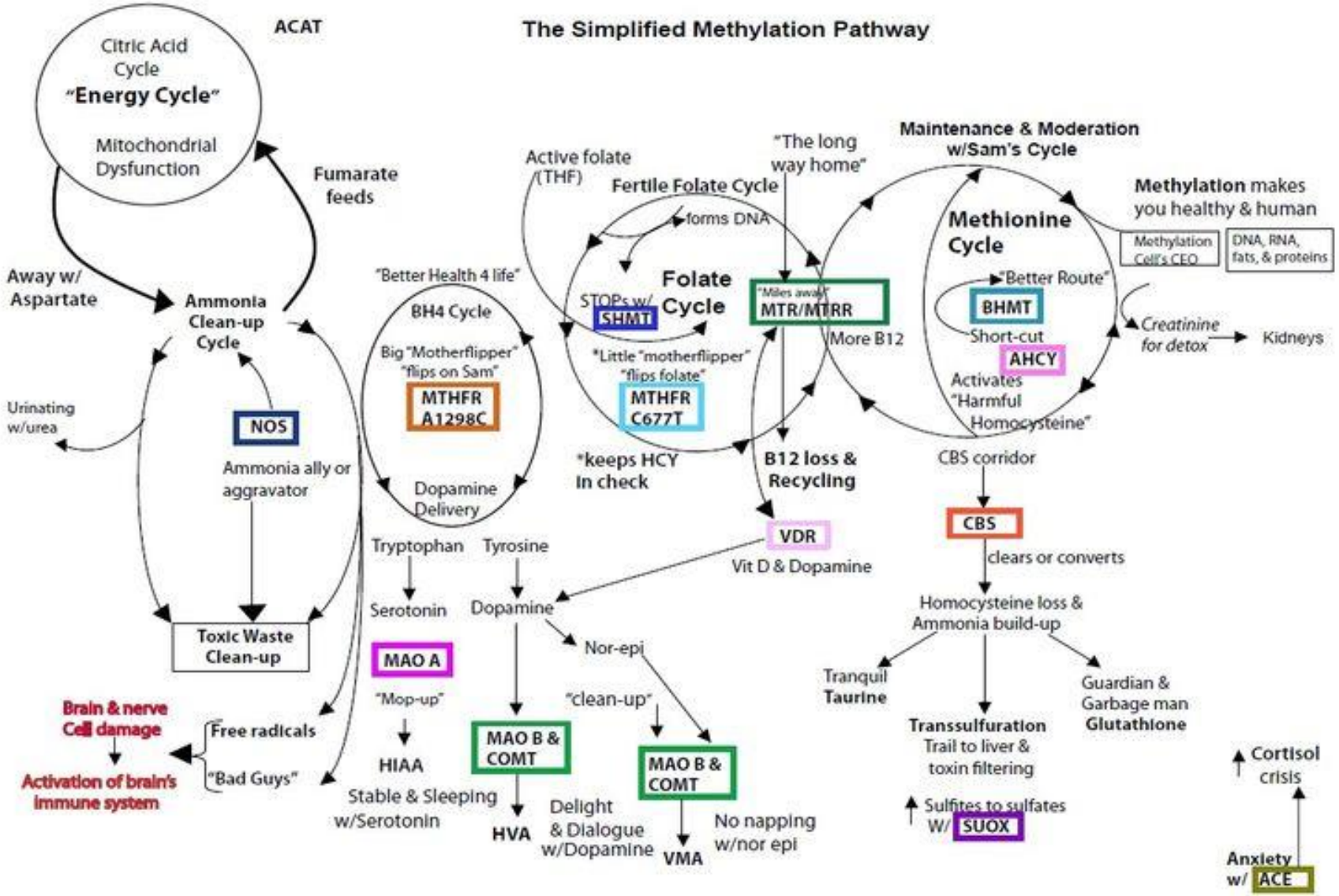
What You Need to Know

The accuracy of genetic testing is not 100%

Results of genetic tests should be taken in the context of clinical representation and familial risk. The prevalence and significance of some allelic variations may be population specific. Your patient may have additional risk that is not measured by this test. Negative findings do not imply that your patient is risk-free.

Methylenetetrahydrofolate reductase polymorphisms:

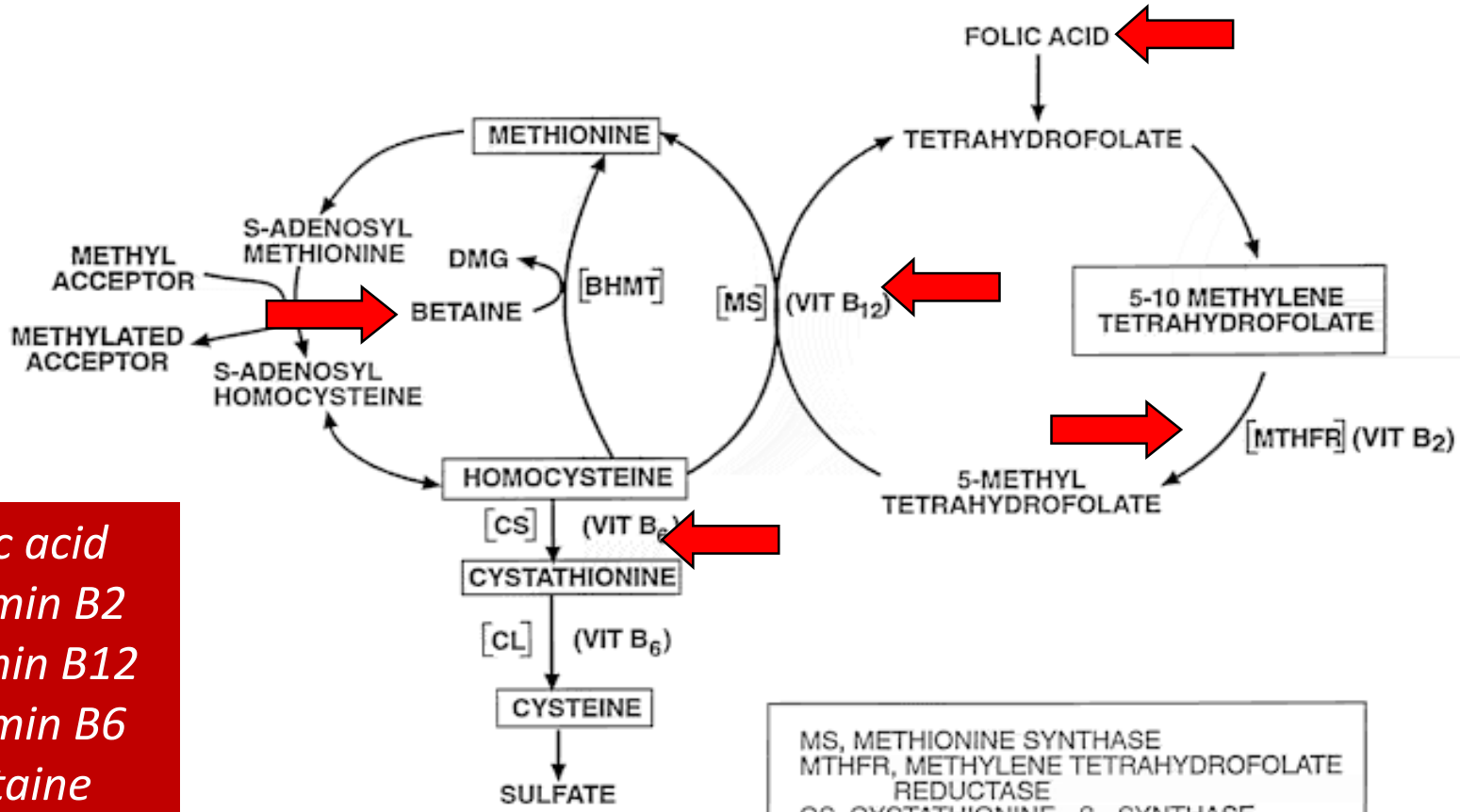
The BIGGEST SNP in Functional Medicine!



Adapted from the Neurological Research Institute's Diagram and simplified by April Ward-Hauge MS, NP

The Yasko Hypothesis of neurological & autoimmune disorders

Your health depends on the transfer of a 1-carbon unit and this transfer depends on nutrients!



Folic acid
Vitamin B2
Vitamin B12
Vitamin B6
Betaine

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More about MTHFR

Two different copies of the MTHFR gene:

- C677T
- A1298C

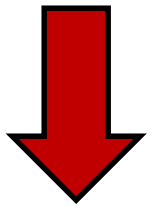
Wild type	-/-	Full strength of the enzyme
Heterozygous	+/-	Some enzyme activity
Homozygous	+/+	Enzyme reduced 60-70%

Disease risk is most pronounced for the homozygous genotype for C677T

Copy of the MTHFR gene:

- C677T

Wild type	-/-	Full strength of the enzyme
Heterozygous	+/-	Enzyme reduced 30-40%
Homozygous	+/+	Enzyme reduced 60-70%

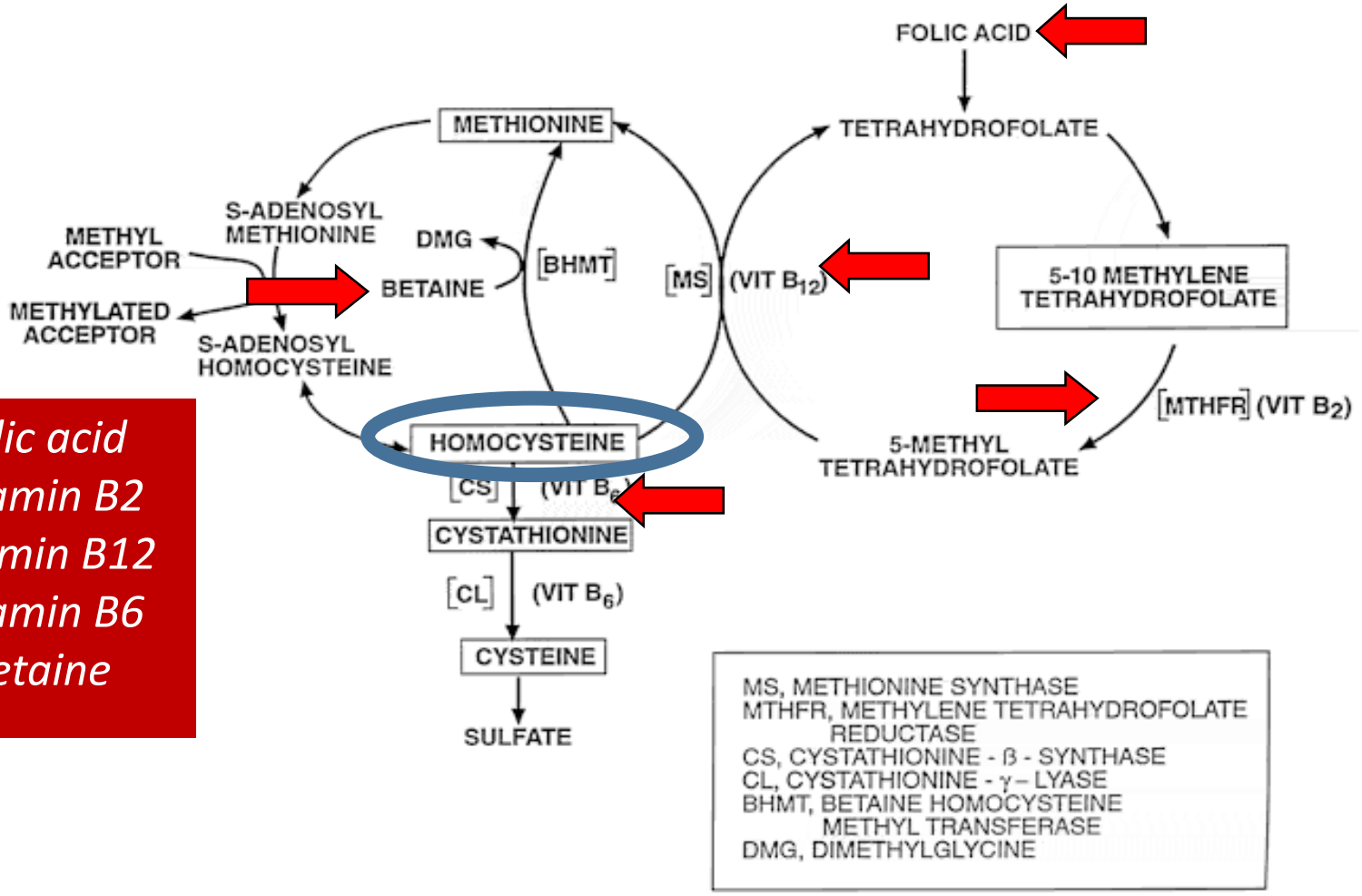


Reduced methylation

Reduced Activity of MTHFR: Clinical Conditions

- Alzheimer’s Disease
- Anxiety
- Cancer
- Cognitive Decline
- Depression
- Heart Disease and Stroke
- Obsessive Compulsive Disorder
- Spina Bifida and NTDs

Biomarkers Related to Methylation: Homocysteine (Hcy)



Folic acid
Vitamin B2
Vitamin B12
Vitamin B6
Betaine

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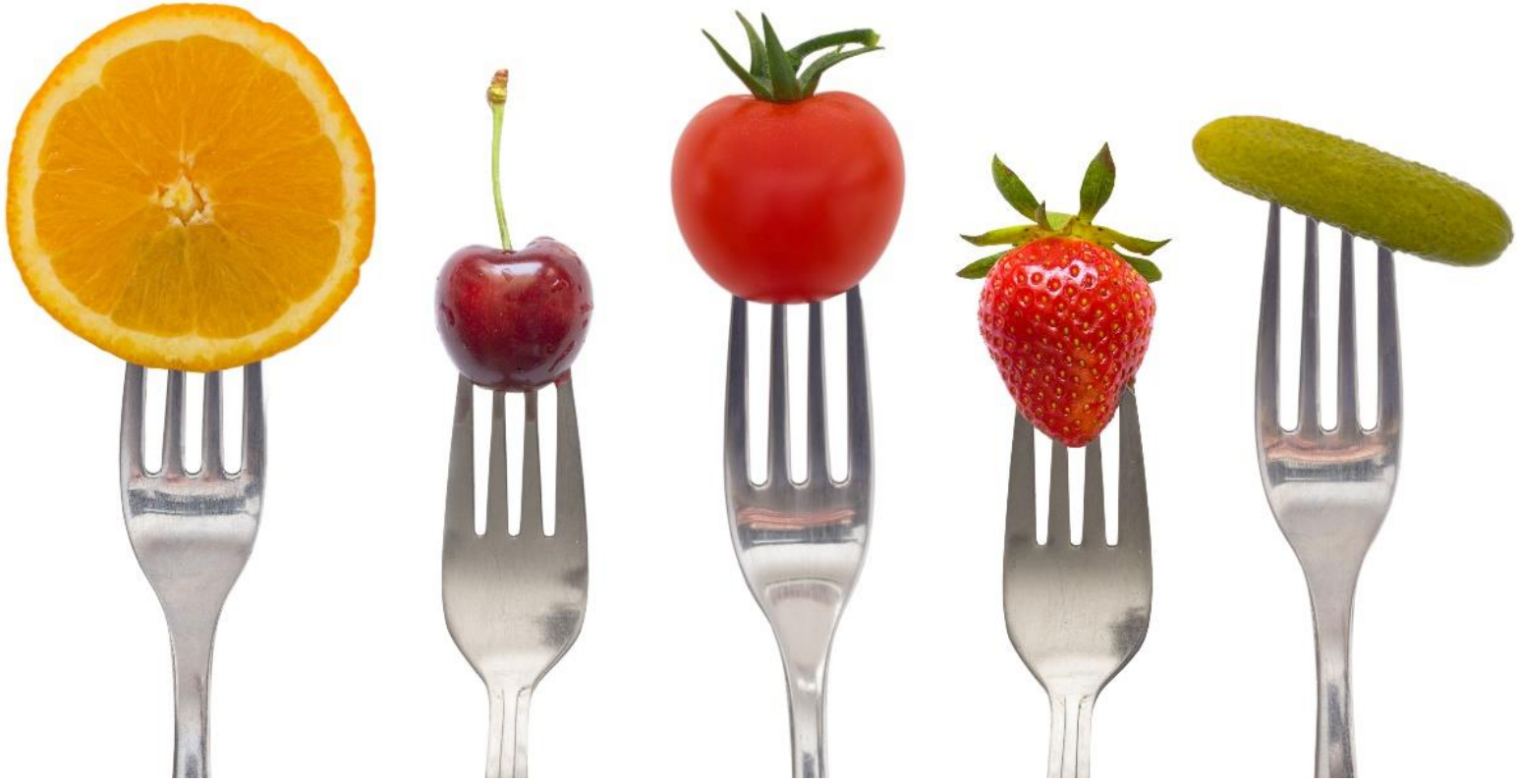
Biomarkers Related to Methylation: Homocysteine (Hcy)

- Increased risk of high homocysteine, especially when there are low levels of B vitamins, mainly folate
- Several studies also suggest tendency for lower folate levels
- Moderate total Hcy elevations have been found to correlate with hypomethylation of DNA in lymphocytes
- Vascular problems associated with hyperhomocysteinemia may be partly due to DNA hypomethylation

Can we rely solely on Hcy levels to tell us something about methylation?

Short answer: NO

What nutritional and lifestyle therapies would you recommend for someone with a MTHFR SNP?



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Reduced Activity of MTHFR (C677T): Treatment Strategies

FOOD FIRST

- Ensure adequate intake of dark-green leafy vegetables and other B vitamin-rich foods

Reduced Activity of MTHFR (C677T): Treatment Strategies

SUPPLEMENTATION

- Consider supplementation with:
  - Folic acid (preferentially 5-methyltetrahydrofolate, which bypasses the MTHFR step)
  - B2
  - B6 (pyridoxal 5-phosphate)
  - B12 (or methylcobalamin)
  - Betaine (trimethylglycine)

Reduced Activity of MTHFR (C677T): Treatment Strategies

LIFESTYLE

- Smoking cessation, if applicable
- Chronic heavy drinking is to be strongly discouraged due to inhibition of methionine synthase, folate depletion in mitochondria and abnormal DNA synthesis and DNA methylation

Methylenetetrahydrofolate reductase polymorphisms:

Summary & Key Clinical Messages

MTHFR Summary Snapshot

1. What is it?
   - Key enzyme involved in methylation
2. When is it clinically indicated?
   - Hyperhomocysteinemia, low B vitamin levels, mainly folate; increased risk of venous thrombosis, CVD, HTN, stroke, diabetic neuropathy or retinopathy, depression, autism, and schizophrenia; increased risk of birth defects (NTDs or congenital heart defects, cleft lip and/or palate, and Down syndrome); increased risk of recurrent pregnancy loss; increased risk of fracture and/or low BMD; increased risk of all cancers; NAFLD
3. How does it compare to other commonly used diagnostics?
   - Should be used in combination with other markers, not as a standalone
4. What are the clinical implications of an abnormal result?
   - Possible impaired methylation, low B vitamins, high Hcy
5. What are other nutrients to consider?
   - Mg, Zn, Fe, B2, B6, B12, Folate/5-MTHF, TMG/Betaine
6. What is the treatment for impaired activity?
   - Dietary and supplemental sources of B vitamins, healthy lifestyle

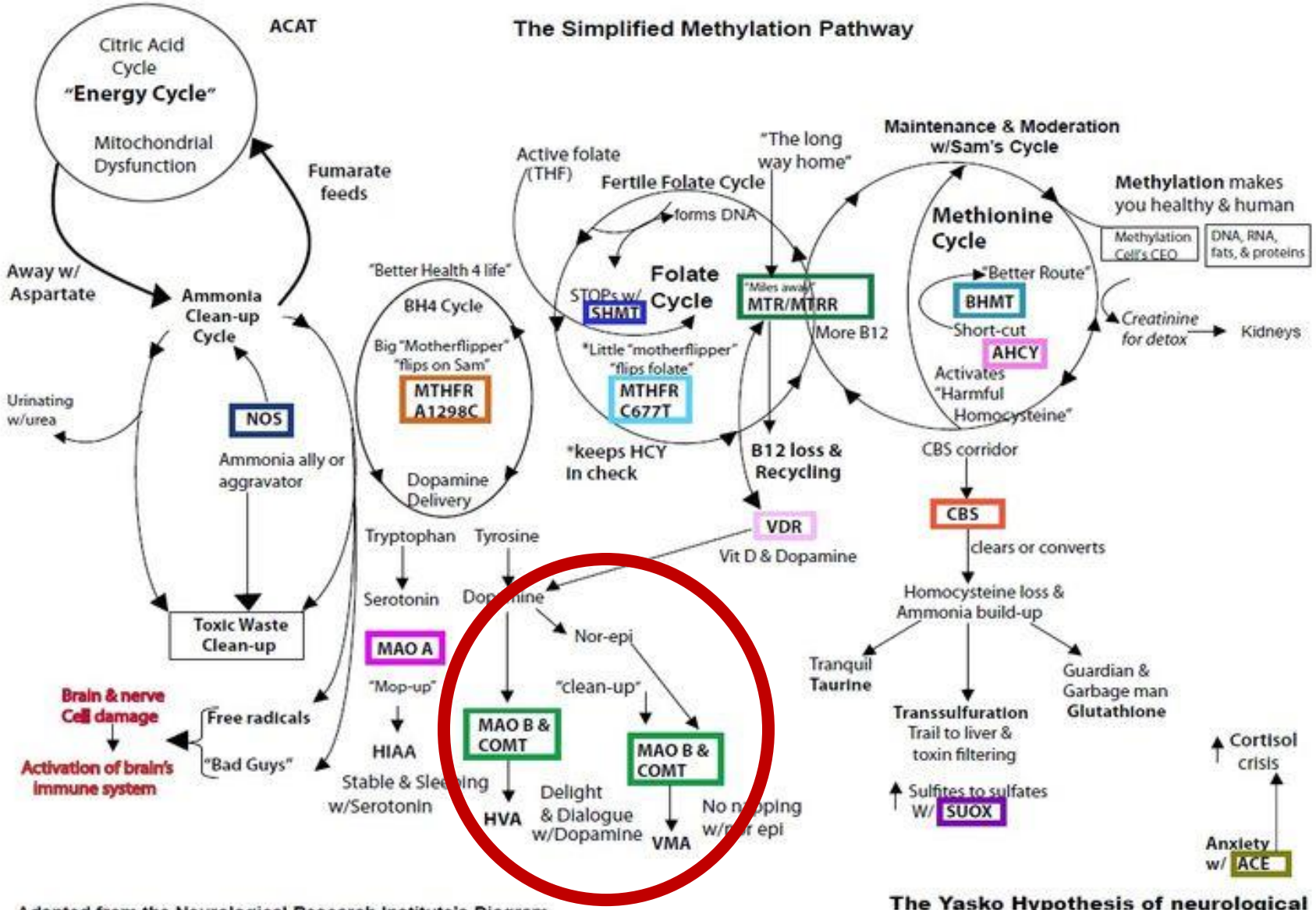
Catechol-O-Methyltransferase:

Think hormones, toxins, and neurotransmitters!

About COMT

Enzyme that catalyzes the movement of a methyl group from S-adenosylmethionine to a catechol or a catecholamine

- Dopamine
- Epinephrine
- Norepinephrine
- Estrogens
- Various chemicals (endocrine disruptors) and toxins



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The Yasko Hypothesis of neurological & autoimmune disorders

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COMT Variant: 158

- The COMT gene has a well-studied, common variant at codon 158
- Those with valine (Val158) alleles have greater COMT activity compared with those with the methionine (Met158) substitution

COMT 158V→M
+ + (Homozygous, most impaired)

- 3-4-fold reduction in COMT enzyme activity, resulting in decreased methylation
- Increased risk of nervousness/anxiety (especially when history of childhood trauma and PTSD) due to higher baseline levels of catecholamines; may be population dependent
- Acute or chronic stress can compromise working memory, decision-making ability, or mood by producing supraoptimal dopamine levels
- Strong cognitive stability, e.g., ability to focus (due to higher brain dopamine), but lower cognitive flexibility (e.g., ability to adapt to external changes), compared to the other genotypes

COMT 158V→M
+ + (Homozygous, most impaired)

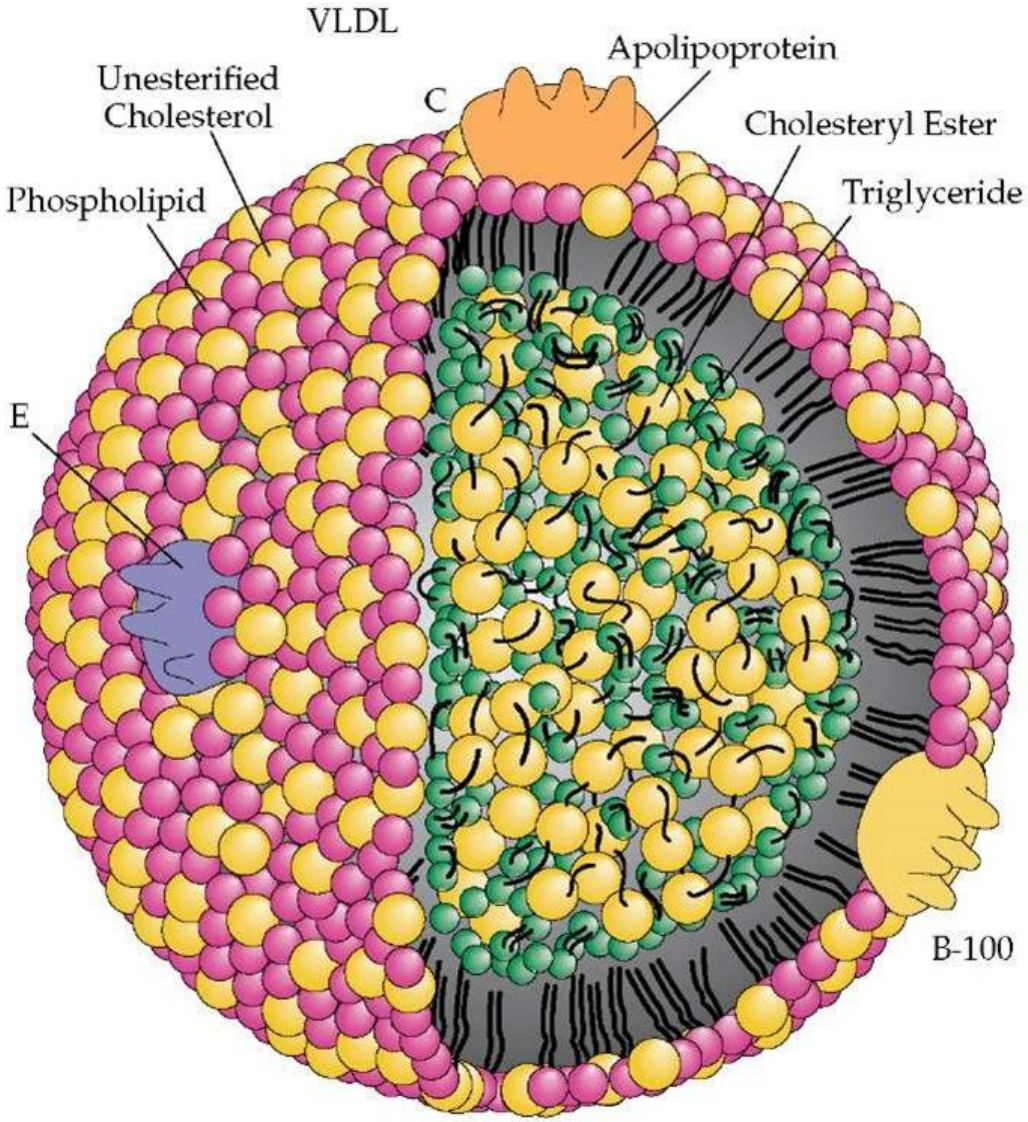
- Conflicting reports for breast cancer risk, possible increased risk in Asian women, but marginally decreased risk in Caucasian women
- Reduced pain threshold which is exacerbated by one's experience of pain, increased risk of fibromyalgia and chronic pain syndromes
- Increased fracture risk, esp. in men, but greater BMD response to physical activity
- Possible increased risk of substance addiction, including alcoholism
- Possible increased risk of Parkinson's disease (mixed studies)

COMT 158V→M
+ + (Homozygous, most impaired)
Treatment Options

- Minimize stress to keep catecholamines low
- Ensure adequate B6, B12, folate, magnesium, betaine, and methionine to support formation of SAM and prevent elevated Hcy; SAH inhibits COMT activity
- Preliminary findings suggest reduced risk of cardiovascular events by taking aspirin or vitamin E
- Exercise caution using CEEs (e.g., Premarin); in-vitro studies show one of its metabolites to inhibit COMT in this genotype
- Individuals with this genotype may have a superior response to SSRI antidepressants (mixed studies)
- In children with ADHD, methylphenidate (Ritalin) may be less effective (mixed studies)

Apolipoprotein E:

Think lipids, CVD and dementia


VLDL
Apolipoprotein
Unesterified
Cholesterol
C
Cholesteryl Ester
Triglyceride
Phospholipid
E
B-100

Apolipoprotein E:

Physiology and Function

A multifunctional lipid-transport protein with central roles in:

- lipid metabolism
- brain lipid transport
- glucose metabolism
- neuronal signaling
- neuronal inflammation
- mitochondrial function

Apolipoprotein E:

Physiology and Function

- Human APOE exists as three major isoforms:
  - APOE2
  - APOE3
  - APOE4

- The parent form, APOE3, promoting clearance of triglyceride-rich lipoproteins and stabilization of plasma lipids

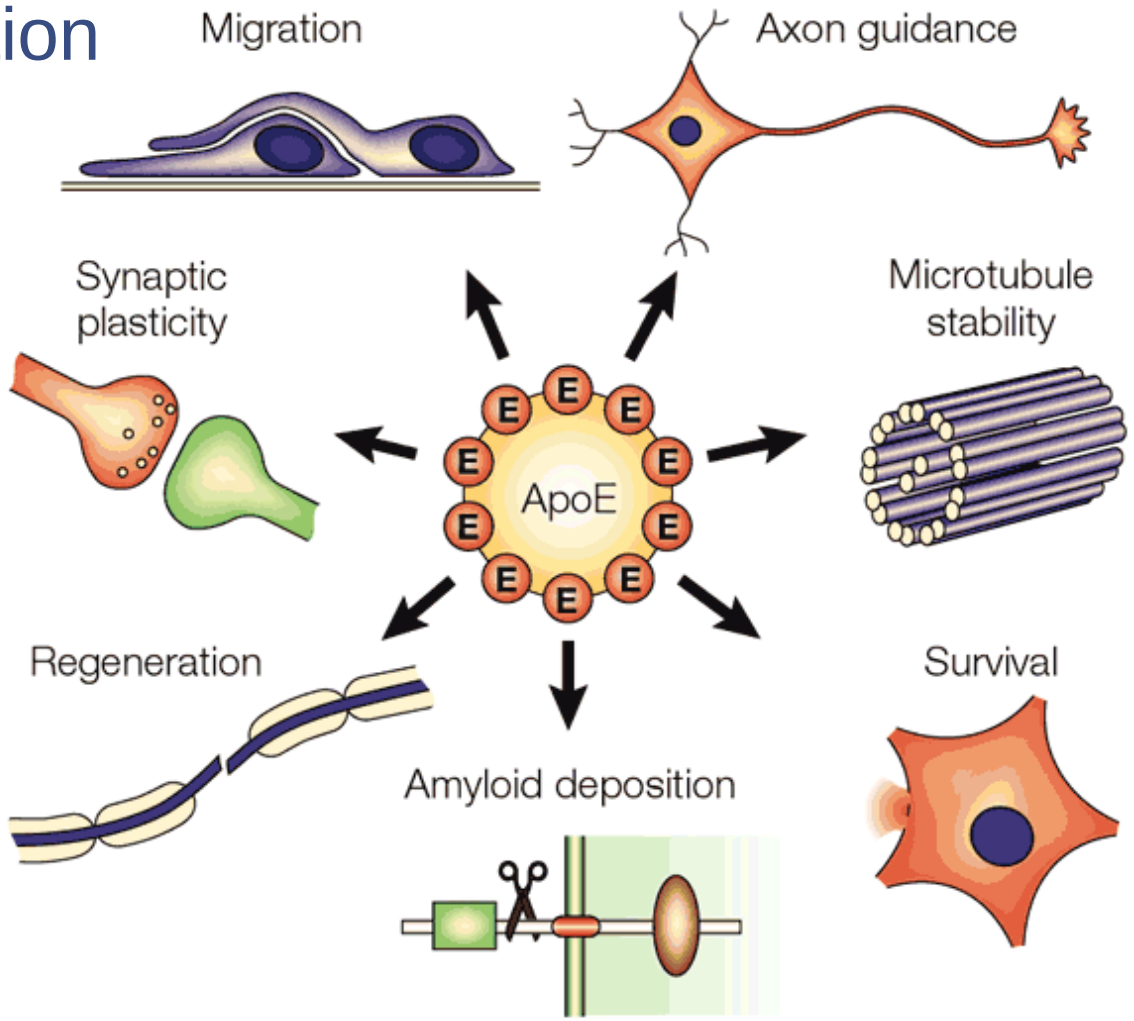
Apolipoprotein E:

Gene Variant Possibilities

- E2/E2
- E2/E3
- E2/E4
- E3/E3
- E3/E4
- E4/E4

Apolipoprotein E:

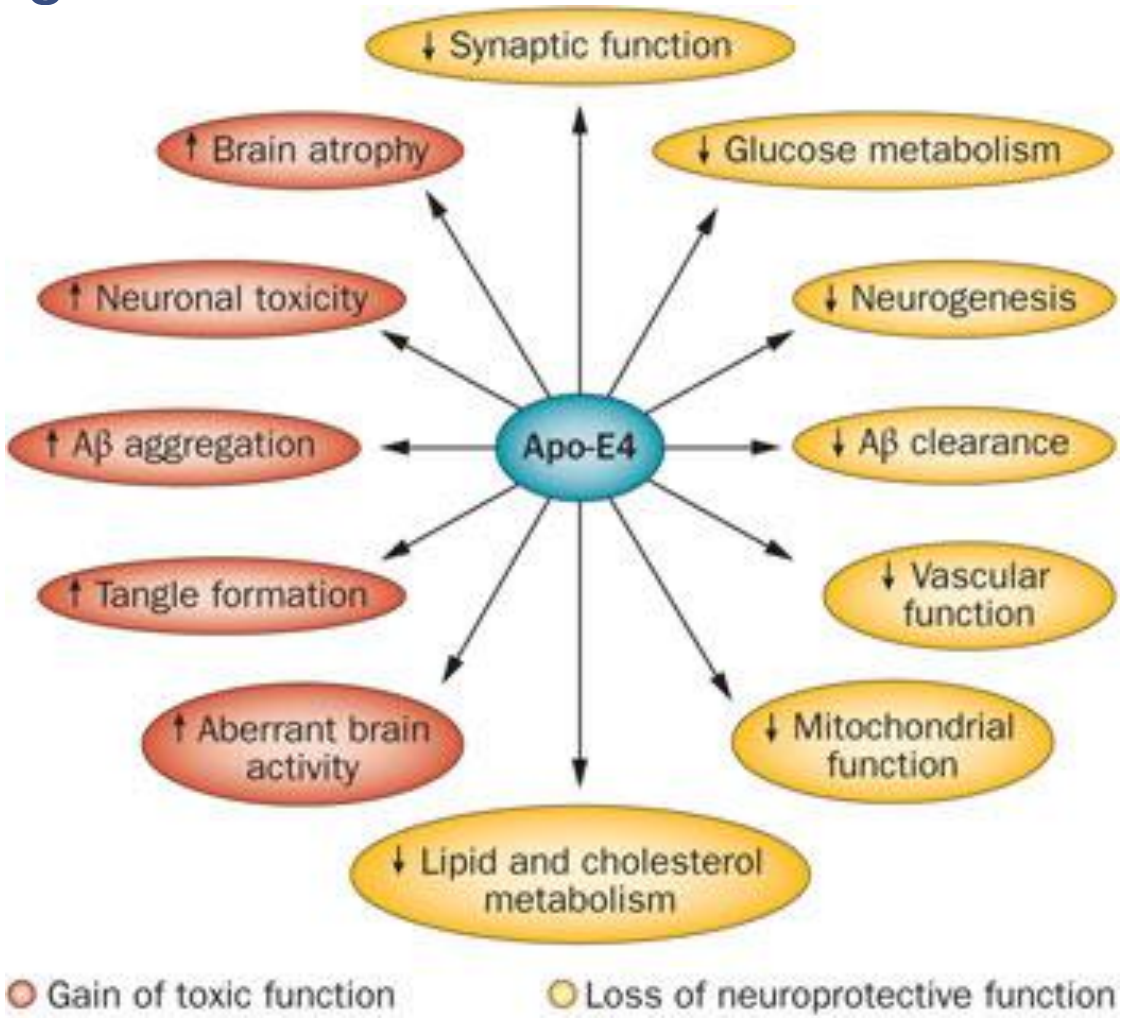
Role in neuroscience & cognition



Nature Reviews | Neuroscience

Apolipoprotein E:

Role in neuroscience & cognition



Apolipoprotein E:
E2/E2

- The E2/E2 genotype is rare, accounting for less than 1% of a given population
- ApoE2 is associated with lower LDL-C and higher HDL-C, but higher TGs
- Slight increased risk of type 2 diabetes and diabetic nephropathy
- Higher uric acid levels in Chinese population
- Generally associated with the lowest risk of atherosclerosis, MI and stroke; however, CAD and MI risk may increase with elevated TGs
- Tendency toward higher plasma C-RP despite lower CV risk.
- Lowest risk of osteoporosis; highest antioxidant activity
- APOE E2/E2 genotype is a potential genetic risk factor for vertebral fractures in humans (newer research, 2014)

Apolipoprotein E:
E2/E2 Treatment Options

- The cholesterol-lowering effect of a low saturated fat and low cholesterol diet is least profound in E2 individuals
- Minimize sugar and high-glycemic index foods, which produce the largest TG response in this genotype
- Fish oils may reduce TGs the most effectively in E2 carriers
- Alcohol may reduce LDL-C in men (neutral in women), but may increase risk of hemorrhagic stroke in men (at least in Asians)
- Lipid response to statins, as well as the TG response to fibrates, are usually the best in E2 > E3 > E4; studies are mixed
- Gemfibrozil may help lower TGs and total cholesterol
- HRT improves the lipid profile in this genotype, although oral estrogen may significantly increase TGs

Apolipoprotein E:
E3/E3

- Most common (accounting for >50% of most populations) and is the genotype against which E2 and E4 are compared
- E3/E3 may be protective against stroke compared with other genotypes, particularly in females
- ApoE3 confers only a moderate tendency toward elevated total- and LDL cholesterol, and lower HDL-C
- Risk is intermediate between E2 and E4 for atherosclerosis, MI, stroke (in smokers), and osteoporosis
- The E3 genotype led to an approximate 90% increase in the levels of TG in the presence of abdominal obesity

Apolipoprotein E:
E3/E3 Treatment Options

- Effects of cholesterol and dietary fat on serum cholesterol levels are least profound with the E2 allele and greatest with the E4 allele; thus, dietary fat restriction produces a moderate cholesterol response in E3/E3 individuals
- Carbohydrate intake may be inversely correlated with HDL-C
- Alcohol may have a neutral effect on LDL-C
- Avoid smoking, which increases risk of CAD in this genotype
- Lipid response to statins, and triglyceride response to fibrates, are usually the best in E2 > E3 > E4; studies are mixed
- HRT generally improves the lipid profile in all genotypes, including post-menopausal E3 carriers

Apolipoprotein E:
E4/E4

- The E4/E4 genotype is rare, accounting for less than 3% of a given population
- Highest total- and LDL cholesterol, lowest HDL-C
- Increased risk of stroke (esp. among Asians), hypertension, and MI; also increased risk of cognitive impairment after stroke; possibly lower CRP levels, despite higher CV risk
- May be an independent predictor of CAD and type 2 diabetes, especially in obese individuals and smokers
- Increased risk of low BMD, oxidative stress, also easier toxicity by heavy metals such as lead and mercury
- Possible increased risk and disease severity of multiple sclerosis

Apolipoprotein E:
E4/E4 Treatment Options

- Reduce stress due to poor response to stressors; prolonged stress contributes to memory decline
- Restricting saturated fat and cholesterol reduces total- and LDL cholesterol, as well as CAD and MI risk
- Avoid smoking and minimize high-GI foods, both of which augment E4-associated risk of CHD
- Alcohol may raise LDL-C in men (neutral effect in women), increase IL-6 levels, and fail to raise HDL-C
- Reduce excess weight, which synergizes with effects of E4 on insulin and lipids
- Fish oils may lower triglycerides but increase LDL-C; mixed studies
- Physical activity and fiber both benefit lipid levels
- Antioxidants may help to counteract low tissue levels; anti-inflammatories help preserve cognition
- Response to statins/fibrates, usually the most positive in E2>E3>E4; studies are mixed
- Estrogen therapy particularly efficacious for both cholesterol and bone in postmenopausal E4 carriers
- APOE4 carriers with BMI ≥25.5 may need higher intakes of DHA for cardiovascular or other health benefits than do noncarriers (Chouinard-Watkins et al., 2015)

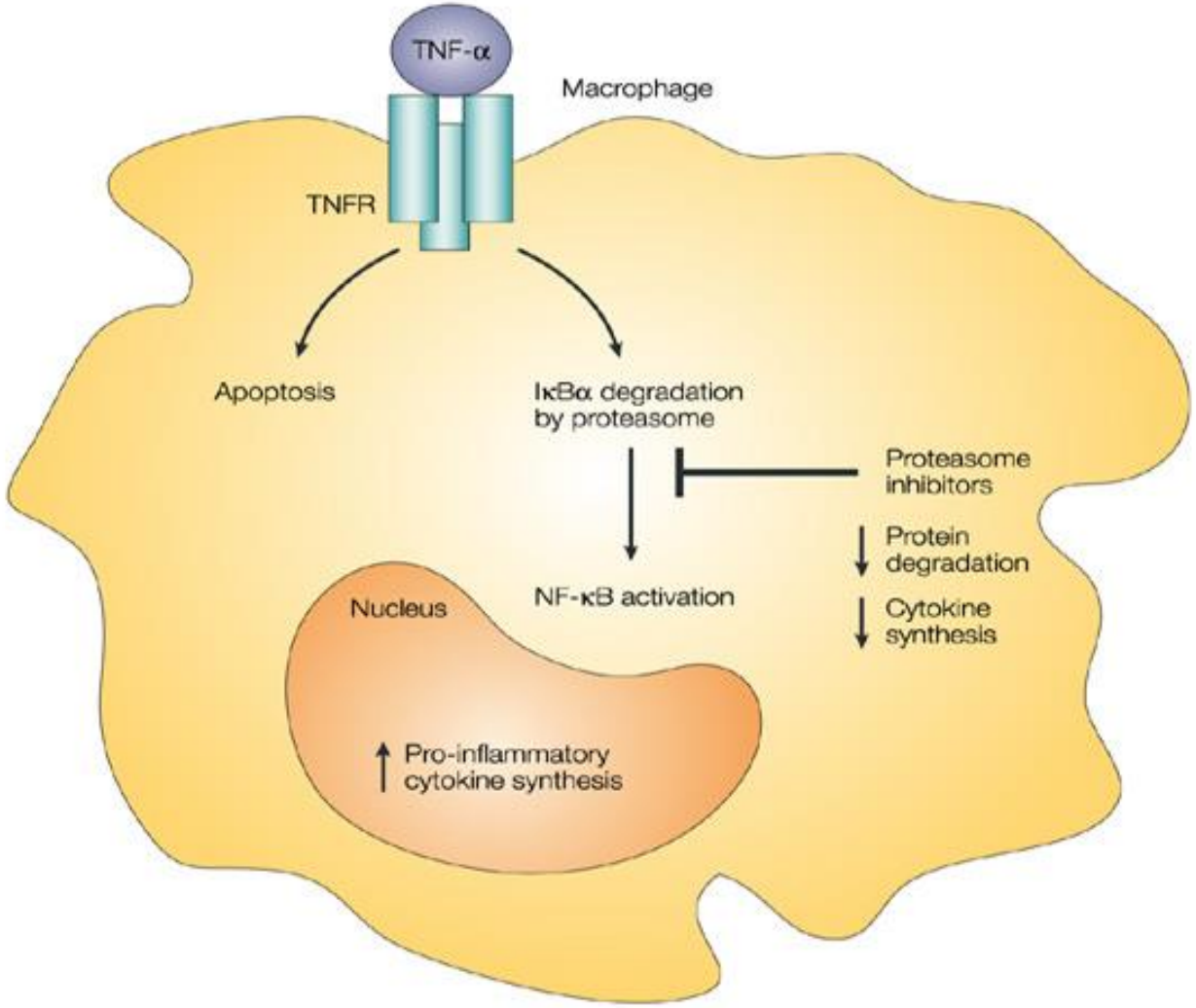
APOE Summary Snapshot

1. What is it?
   - Key protein involved in transport of lipids
2. When is it clinically indicated?
   - Plasma lipid abnormalities such as high TGs, high LDL-C, low HDL-C; increased risk for T2DM, atherosclerosis, MI, stroke; indications of high inflammation such as elevated C-RP and hyperuricemia; low BMD or increased risk for OP and fractures; indications of oxidative stress/low antioxidant status and heavy metal toxicity.
3. How does it compare to other commonly used diagnostics?
   - Should be used in combination with other markers, not as a standalone
4. What are the clinical implications of an abnormal result?
   - Possible increased risk of high lipids, CVD, and/or dementia
5. What are other nutrients to consider?
   - Cardiovascular and neurological supportive nutrients
6. What is the treatment for impaired activity?
   - Minimize stress, healthy diet low in sugar and high in nutrients

Tumor Necrosis Factor-alpha:

The inflammation ‘monster’

TNF-alpha



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TNF-alpha:

What is it?

- TNF-alpha (TNF-α) is a pro-inflammatory cytokine that is secreted from activated macrophages
- TNF-α plays an important role in host defense against infection; however, excessive release of the cytokine increases inflammation and oxidative stress

TNF-alpha:

Genetic variability

- Several SNPs in the TNF gene promoter have been identified, some of which may regulate TNF expression
- One of these polymorphisms at position -308 (TNF -308 G/A) had been reported to affect cytokine production and be associated with regulation of TNF expression by, e.g., interfering with transcription factor binding sites or other regulatory elements

TNF-alpha:

308G→A +/+ (Greatly increased activity)

- Substantially increased production of TNF-α, risk of inflammation and oxidative stress
- All the same clinical issues seen with the +/- genotype
- Increased risk of OA (Kou and Wu, 2014)
- Elevated risk for acne vulgaris among Caucasians (Yang et al., 2014)

TNF-alpha:

308G→A +/+ (Greatly increased activity)

Treatment Options

- Abdominal fat loss; visceral fat produces TNF-α and IL-6, and weight loss is associated with a decrease in these inflammatory cytokines
- Improve insulin sensitivity
- Control stress response
- Individuals with the SNP are more prone to weight gain and an abnormal cholesterol profile from a high intake of saturated fat and/or n-6 fatty acids
- TNF-α levels may be reduced by vitamin E, fish oils, N-acetylcysteine, green tea, Siberian ginseng, nettles, lactobacillus, estrogen, and DHEA
- Possible inferior response to anti-TNF-α medications (e.g., etanercept) in rheumatoid arthritis; also possible resistance to steroid treatment for inflammatory conditions

TNF-alpha Summary Snapshot

1. What is it?
   - Proinflammatory cytokine
2. When is it clinically indicated?
   - Presence of all (chronic) inflammatory conditions
3. How does it compare to other commonly used diagnostics?
   - Should be used in combination with other markers of inflammation, not as a standalone
4. What are the clinical implications of an abnormal result?
   - Possible increased risk of inflammation/inflammatory conditions
5. What are other nutrients to consider?
   - Nutrients to reduce inflammation
6. What is the treatment for impaired activity?
   - Minimize stress, low-inflammation diet

SNPs & NutrEval:
Mood Sensitization Disorders

Depression:

- Compelling SNPs: APOE, COMT, MTHFR (mixed)
- NutrEval: B vitamins, omega-3 fatty acids, vitamin C

Summary

- There is a lot we now know about genes
- There is a lot we still don’t know about genes and modulation of the epigenome
- There is still less we know about nutrigenomic application to clinical medicine, but there is some recent data emerging
- Food (and eating) is (are) filled with informational signals delivered to our cells.
- Nutrigenetic testing should be coupled with laboratory nutrient assessment for clinical application
- Note how nutrients come together with genes for a more complete picture/assessment
- MTHFR, COMT, APOE, and TNF-a are some important genes that will assist with clinical therapeutic strategies

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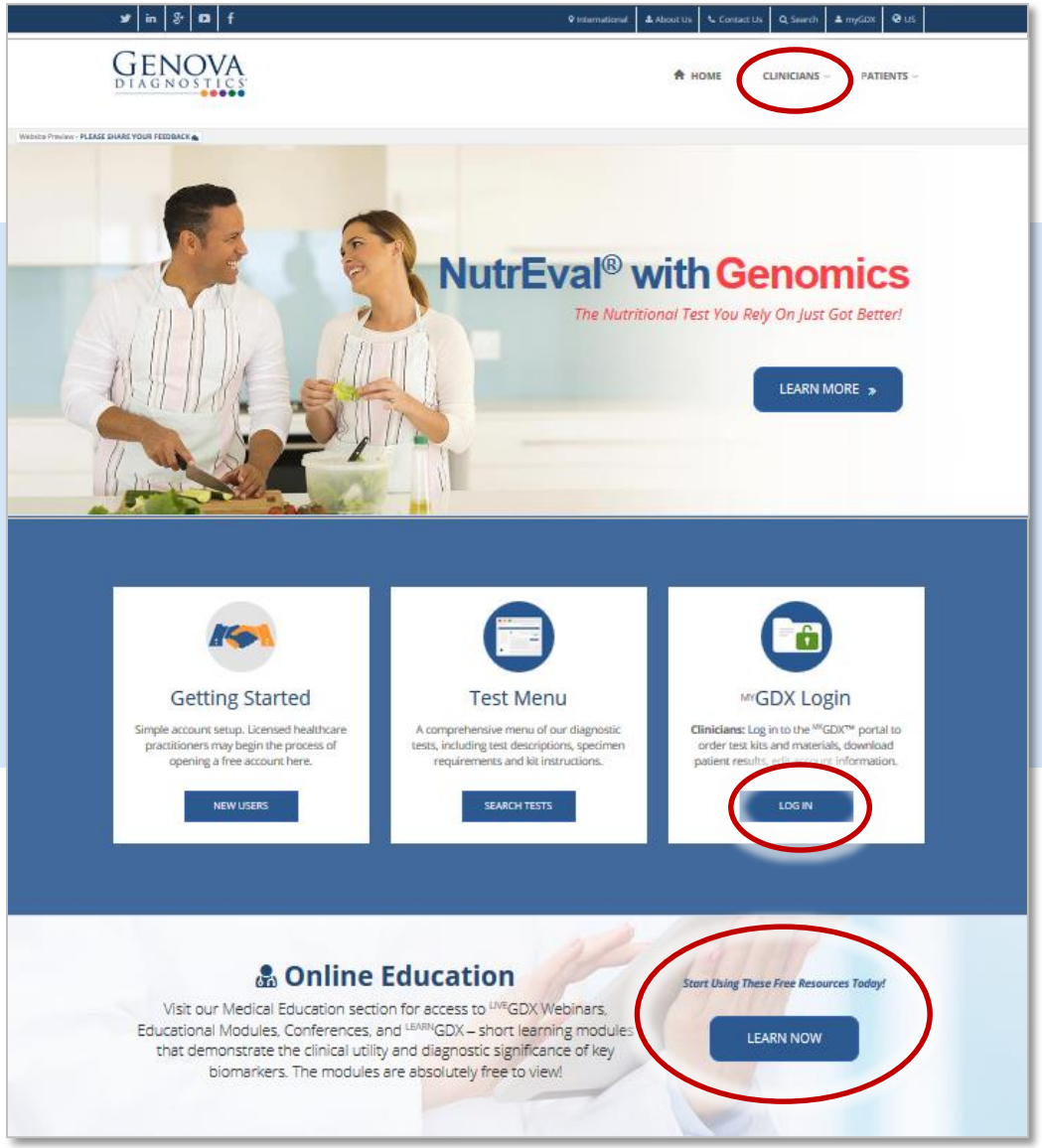

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Nutrigenomics in Clinical Practice: Genes, Food, and Specialty Diagnostics

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