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BLUEPRINTBOOTCAMP

Blood Chem
Advanced Blood Sugar

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Blood Sugar Tests

- ✓ Insulin
- ✓ Hemoglobin A1C
- ✓ Fructosamine
- ✓ C-peptide
- ✓ Glyco Mark
- ✓ Antibodies
  - ➢ Anti-Insulin Antibodies
  - ➢ Anti-Islet cell antibodies
  - ➢ GAD antibodies
  - ➢ Znt8 antibodies

Lab Testing for Insulin Resistance and Blood Sugar Dysregulation - #1

Date Tested	Test	Optimal Range	Notes
	Fasting Glucose	75 - 89	Fasting glucose becomes abnormal after a long standing problem with insulin control.
	Fasting Insulin	2 - 5	High fasting insulin is indicative of a serious insulin dysregulation. Rarely done, but much more useful would be insulin after eating. In most cases it parallels blood sugar, but not all the time.
	Triglycerides	50 - 100	These are fats that have been created from excess carbohydrates.
	HDL	> 50	"good cholesterol"
	Triglyceride/HDL ratio	< = 1	This is a good marker for insulin resistance and sugar dysregulation. Ideal is when the HDL is greater than the triglycerides.
	Hemoglobin A1C	4.8 - 5.0	HBA1C is a measure of the percentage of your blood cells that are glycosalated, i.e. sugar-coated! Indicator of glucose control over previous 3 months. The average glucose level can be determined from the A1C as follows: **A1C (%) / Mean blood sugar:** 4/65; 5/100; 6/135; 7/170; 8/205; 9/240; 10/275; 11/310; 12/345. Available as a home test kit in all major pharmacy chains and online.

Lab Testing for Insulin Resistance and Blood Sugar Dysregulation - #2

Date Tested	Test	Optimal Range	Notes
	Blood Spot Fatty Acid by Metametrix	N/A	Detects imbalances in omega-3 and omega-6 fats that adversely affect insulin sensitivity and can lead to blood sugar imbalances. DHA is particularly important.
	Vitamin D	75 - 100	Improves insulin sensitivity and regulates immune system.
	C-peptide (also known as insulin C-peptide, connecting peptide)	1.1 - 4.4	This test measures residual beta cell function by determining the level of insulin secretion.
	Islet Cell Antibodies (ICA)	< 1	Antibodies that attack the islet cells of the pancreas, the cells that make insulin.
	Glutamic Acid Decarboxylase (GAD) Antibodies	0.0 - 1.5	Glutamic acid decarboxylase (GAD) is an enzyme that is produced primarily by pancreatic islet cells. GAD is an enzyme that makes GABA.
	Insulin Antibodies (IAA)	< 5	Antibodies that attack insulin.
	Adrenal Stress Index	N/A	A panel that measures the adrenal hormones cortisol and DHEA as well as fasting and post meal insulin. Adrenal stress contributes to insulin resistance.

Lab Marker Patterns

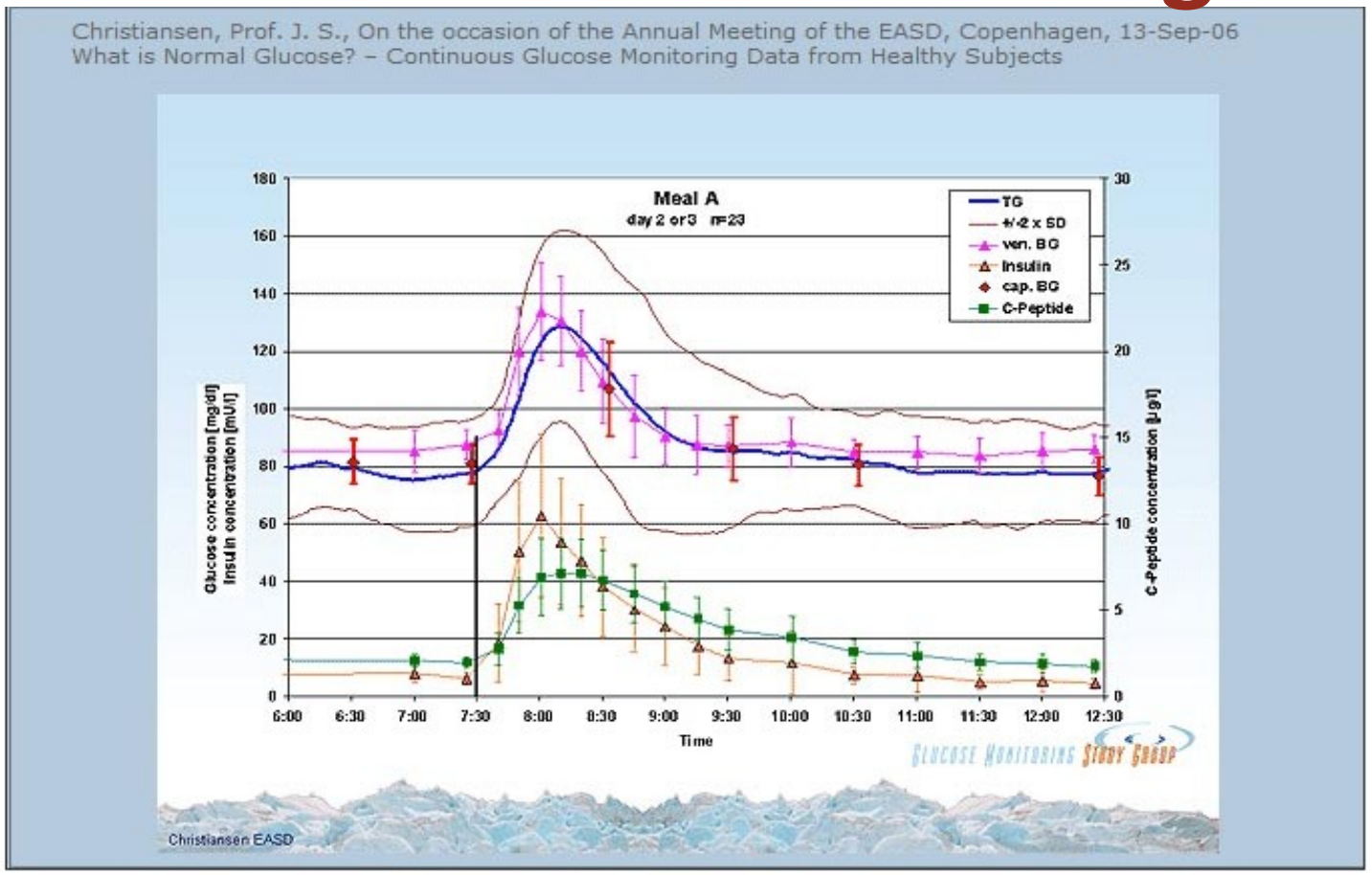
	Normal	Insulin Resistance	Metabolic Syndrome	Diabetes
Fasting Glucose	75-89	90-119	>=100	>=120
Triglycerides	>65	>90	>110	>110
HDL	50-90	<65	<55	<55
Fasting Insulin	2-5	Normal or >5 – varies on stage	>5	>5
Hemoglobin A1C	4.5 – 5%	5.3-6.5%	>5.7%	>5.7%

Assessment of Diabetes

- ✓ **High Glucose:** > 120 on 2 tests
- ✓ **Hemoglobin A1C:** > 6.5 [1]

  1 http://www.drritamarie.com/go/Ref6RoleA1CAssayDiabetes
- ✓ **Triglycerides:** > 110 usually
- ✓ **Cholesterol:** > 220 usually
- ✓ **HDL:** < 55 usually
- ✓ **Blood Pressure:** increased

What is Normal Blood Sugar?

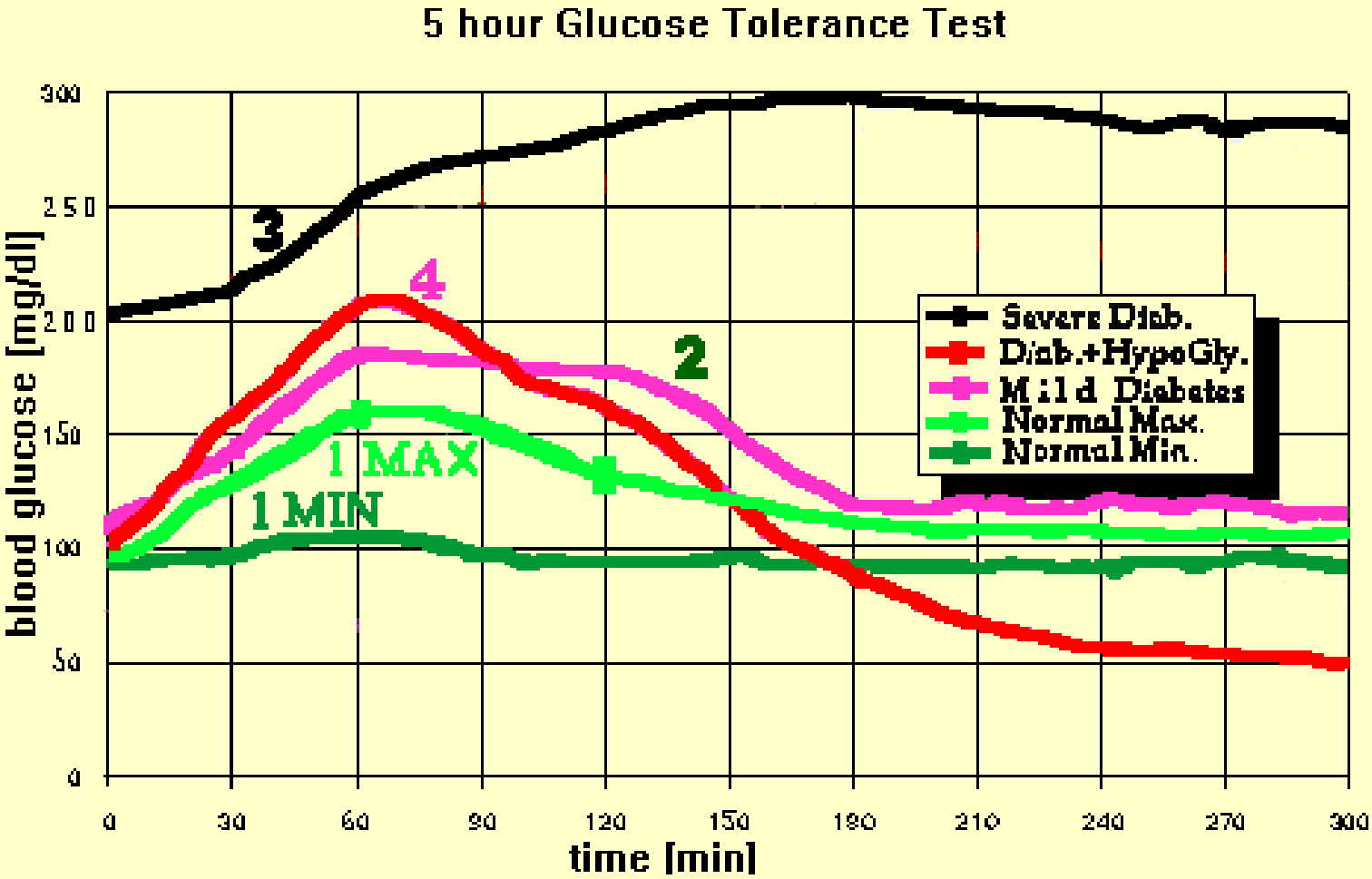


What is a Normal Blood Sugar?

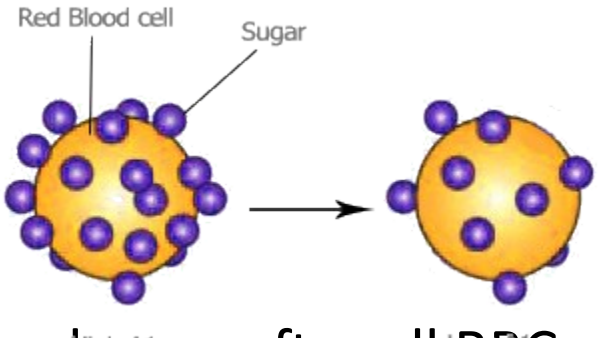
Normal blood sugars after a high carbohydrate breakfast eaten at 7:30 AM. The blue line is the average for the group. The brown lines show the range within which most readings fell (2 standard deviations). Bottom lines show Insulin and C-peptide levels at the same time.Graph is a screen shot from Dr. Christiansen's presentation cited below.

Professor J.S. Christiansen, presented at the Annual Meeting of the EASD.

Response After 100 gram Glucose Solution



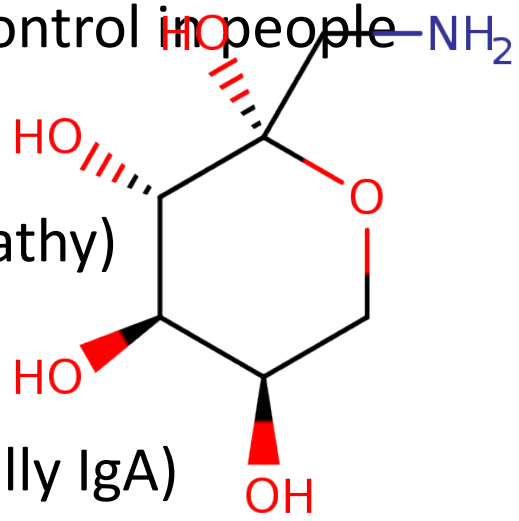
Hemoglobin A1C



- ✓ Indirect measure of blood sugars over a **90 to 120-day period**
- ✓ Glucose gets **attached to hemoglobin** when levels of blood sugar are high
- ✓ **Glycosylation is irreversible** – you'll only see a change after all RBCs have replaced themselves
- ✓ Influenced by conditions affecting RBC survival.
  - ➢ Untreated iron, vitamin B12, or folic acid deficiency anemias can cause falsely high due to low RBC turnover
  - ➢ Hemolytic anemia, and chronic kidney disease and pregnancy can cause falsely low values due to high RBC turnover
- ✓ **Measure** of long-term glucose control
- ✓ Run when glucose is high or low or follow-up for diabetes
- ✓ **Optimal range:** 4.5 - 5.0 %

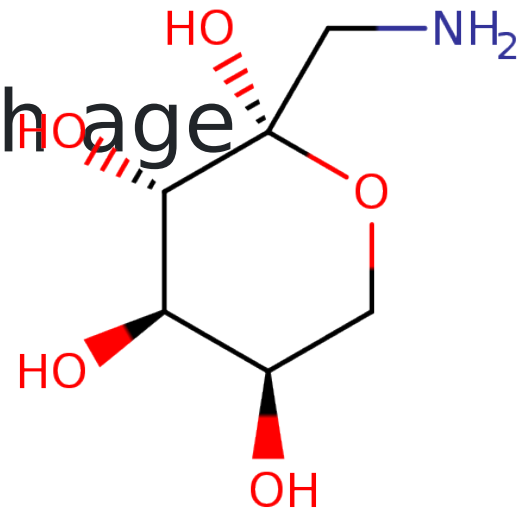
Fructosamine

- Measures glycation of circulating proteins including albumin, globulins, and lipoproteins – mostly albumin
- Similar to Hemoglobin A1C, indicative of long-term glycemic control
- Estimates average glucose levels over past 2-3 weeks vs 3-4 months for A1C
- Not a good screening for diabetes – but good to monitor control
- May not be a good measure of blood sugar control in people who have:
  - thyroid disease
  - intestinal disease (protein-losing enteropathy)
  - kidney disorders (nephrotic syndrome)
  - liver disease
  - increased immunoglobulin levels (especially IgA)



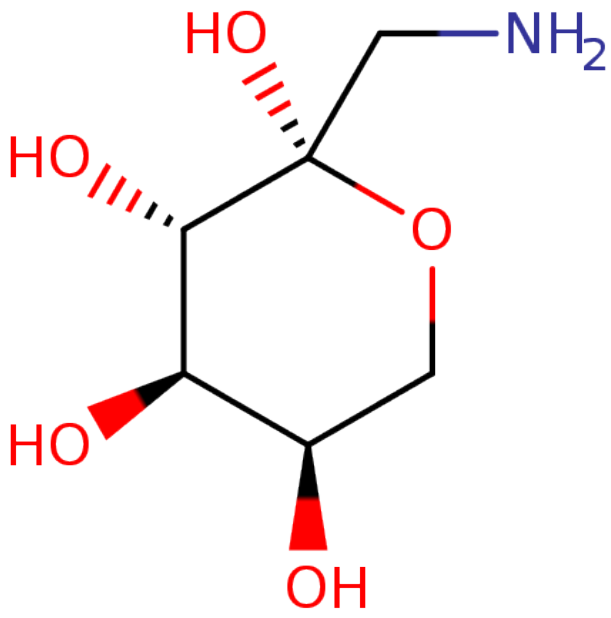
Fructosamine Ranges

- ✓ 190 – 285 umol/L - non-diabetics with normal albumin
- ✓ 210 – 563 umol/L - diabetics
- ✓ Normal range may vary between laboratories.
- ✓ Levels tend to increase with age



Causes of Abnormal Fructosamine

- ✓ **Low**
  - Low Protein
  - Obesity
  - Pregnancy
- ✓ **High**
  - Elevated Blood Glucose
  - UV Exposure
  - Hypothyroidism
  - Increased Antibody Production
  - Iron-deficiency Anemia
  - AIDs
  - Glucocorticoids



Insulin

- **Fasting**
  - Lab ranges 2 – 19 mIU/ml
  - Ideal ranges 2 – 5 mIU/ml
- **Post Prandial**
  - Peaks at approximately 1 hour depending on meal
  - Check in response to a high carb meal
  - Earliest biomarker for identifying pre-diabetes, type 2 diabetes and increased cardiovascular risk https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5708305/
- **Interfering Factors**
  - pregnancy, 2nd to 3rd trimester
  - Diabetes medications

Homeostatic Model Assessment of Insulin Resistance (HOMA-IR)

Fasting Glucose (mg/dl)*Fasting Insulin (mIU/ml) /1000

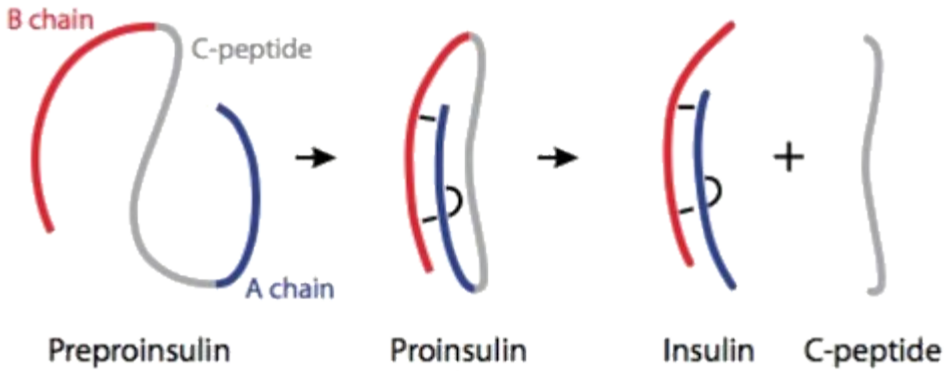
- ✓ Conversions:
  - ➢ glucose(mmol/l) = glucose (mg/dl /18)
- ✓ Indicates how much insulin is needed to keep blood sugar levels in check
- ✓ More practical than measuring insulin resistance directly - hyperinsulinemic-euglycemic glucose clamp
- ✓ Ranges
  - ➢ Ideal range is less than 1
  - ➢ >1.9 - early insulin resistance
  - ➢ > 2.9 - significant insulin resistance.

Quantitative Insulin Sensitivity Check Index (QUICKI)

- ✓ A calculation that predicts insulin sensitivity
- ✓ Developed in the year 2000
- ✓ Inverse of the sum of the logarithms of fasting insulin and fasting glucose: QUICKI = 1 / [log(FI) + log(FG)]
- ✓ Online calculators available: https://www.omnicalculator.com/health/quicki#:
- ✓ Excellent correlation to insulin resistance directly - hyperinsulinemic-euglycemic glucose clamp
- ✓ Range .30 - .45 - below 0.339 indicates insulin resistance, .3 diabetes
- ✓ Decreasing levels suggest trending towards insulin resistance, metabolic syndrome and diabetes

C-Peptide

- ✓ A peptide released during insulin synthesis by pancreatic beta cells
- ✓ Proinsulin split apart to form one molecule of C-peptide and one molecule of insulin.



- ✓ Indicates how well the beta cells are making insulin
- ✓ Done fasting for 8-12 hours
- ✓ Range is 0.5 to 2.0 nanograms per milliliter.

Glyco-Mark

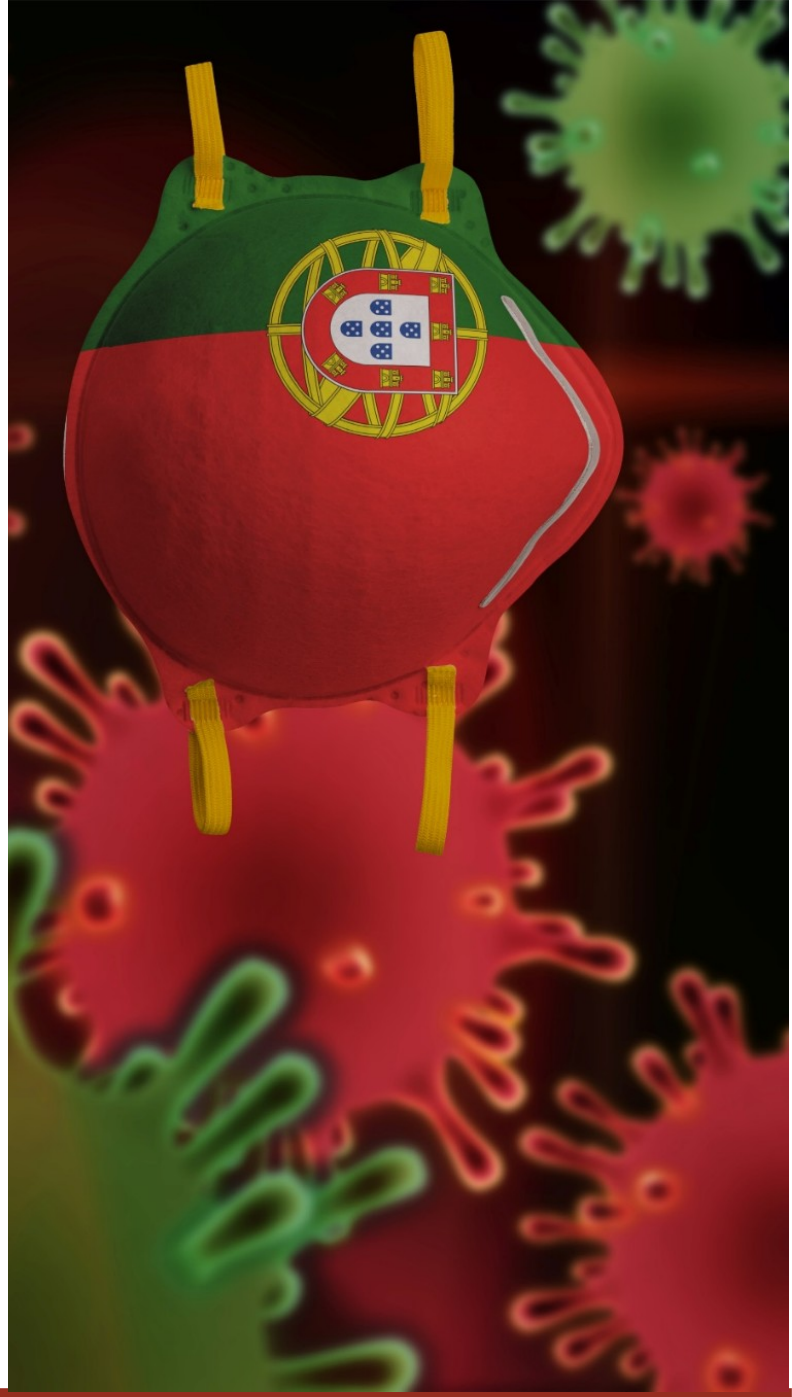
- ✓ Measures excursions in glucose readings via 1,5-Anhydroglucitol (1,5-AG) a monosaccharide in nearly all foods that decreases when glucose above 180 mg/dL, and returns to normal in 2 weeks
- ✓ Indicates average maximum glucose over last 2 weeks
- ✓ Useful when people aren't able to get a CGM

	Glucose	A1C	GlycoMark
Glucose detection	Actual	Average	Glycemic variability, hyperglycemic excursions (fasting, postprandial, or both)
Timeframe	Current **At blood draw**	Long term **Prior 2-3 months**	Recent/intermediate **Prior 1-2 weeks**
Independently associated with outcomes	✓	✓	✓
Specific to recent hyperglycemia and glycemic excursions			✓

https://glycomark.com/the-glycomark-test/
https://glycomark.com/wp-content/uploads/2020/01/M-54-1C-DetailAid-Approved.pdf

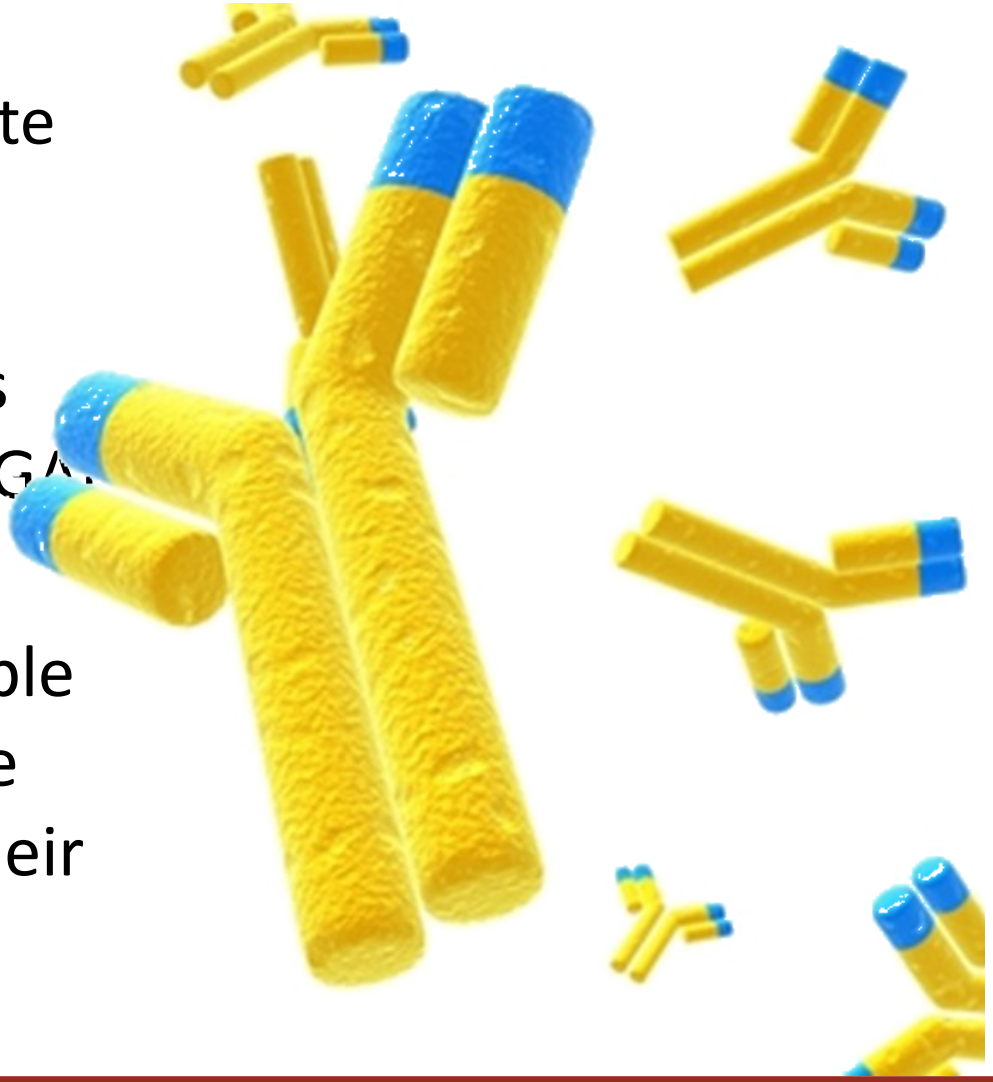
Blood Sugar Related Antibodies

- ✓ Glutamic Acid Decarboxylase Antibodies (GAD-65)
- ✓ Anti-Insulin Antibodies (AIA)
- ✓ Anti Islet Cell Antibodies(ICA)
- ✓ Zinc transporter autoantibodies (ZnT8)
- ✓ Tyrosine phosphatase antibodies



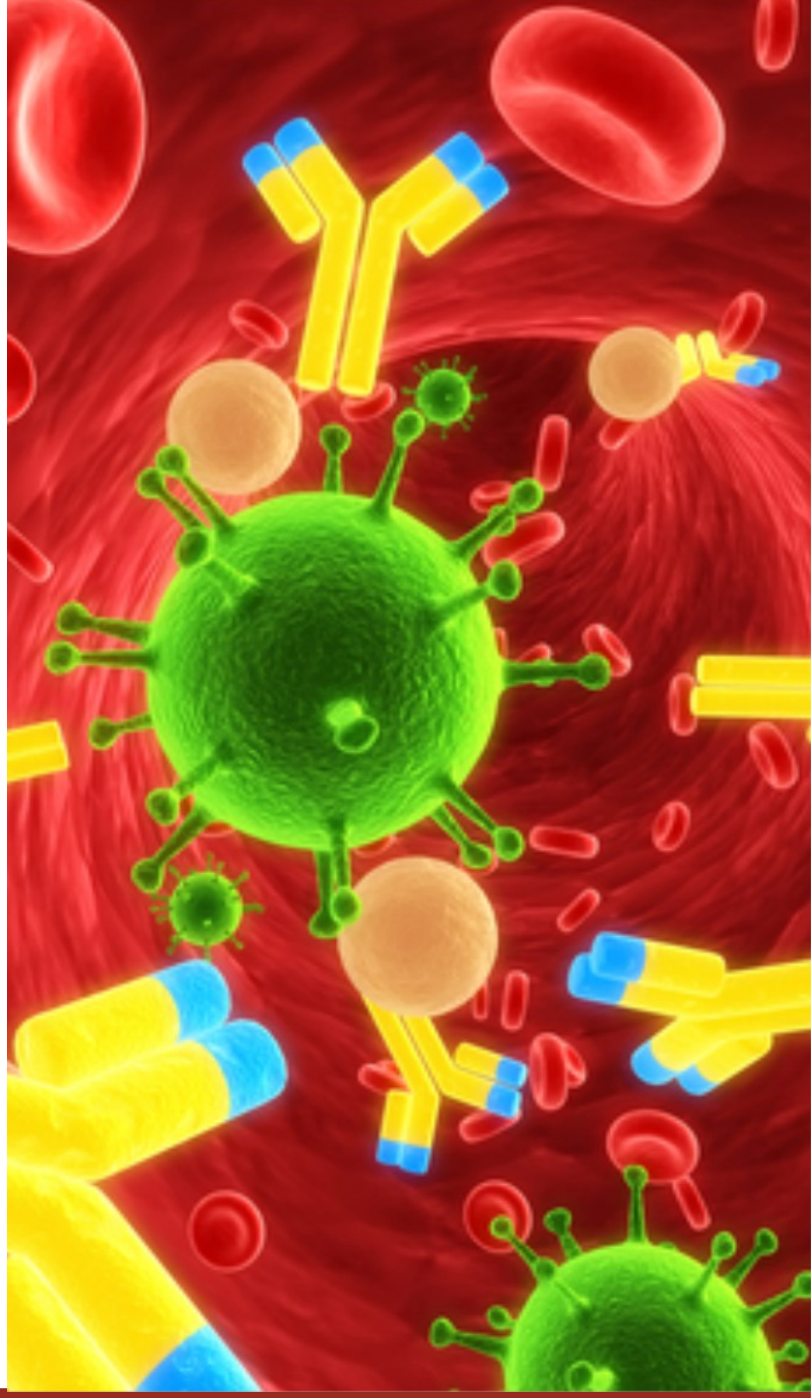
Glutamic Acid Decarboxylase Antibodies

- ✓ Causes increased glutamate and decreased GABA in pancreas
- ✓ Beta cells in the pancreas secrete GABA, and need GA to function normally
- ✓ About 75 percent of people with type 1 diabetes have GAD autoantibodies in their blood.



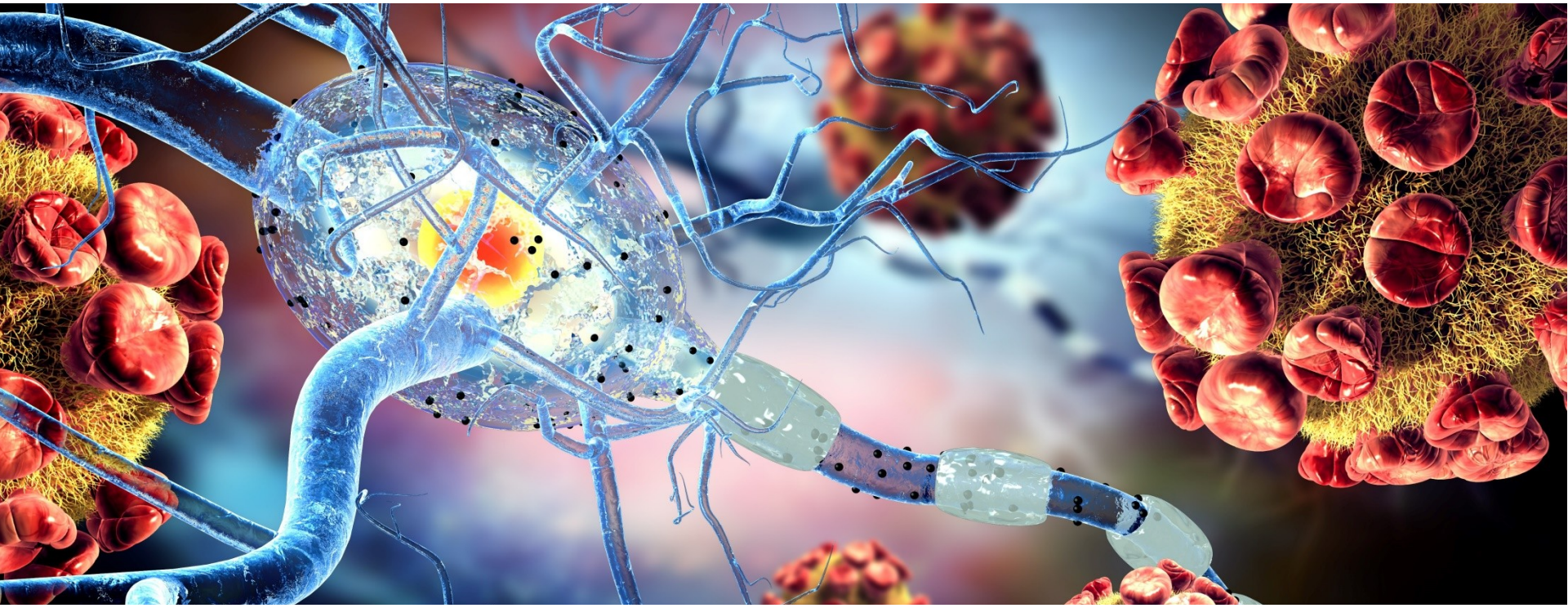
Anti-Insulin Antibodies (IAA)

- ✓ Attack insulin
- ✓ Present in 55% of type 1 diabetics
- ✓ Prevalence correlates inversely with age at onset of diabetes
- ✓ Usually, the first marker in young children at risk for diabetes
- ✓ IgM and IgG decreases effectiveness of insulin
- ✓ IgE in people taking insulin can result in allergic reaction at injection site



Anti-Islet Cell Antibodies (ICA)

- ✓ Intra-cytoplasmic antibodies attack the islet cells in pancreas
- ✓ Damage to the islet cells decreases their effectiveness at making insulin

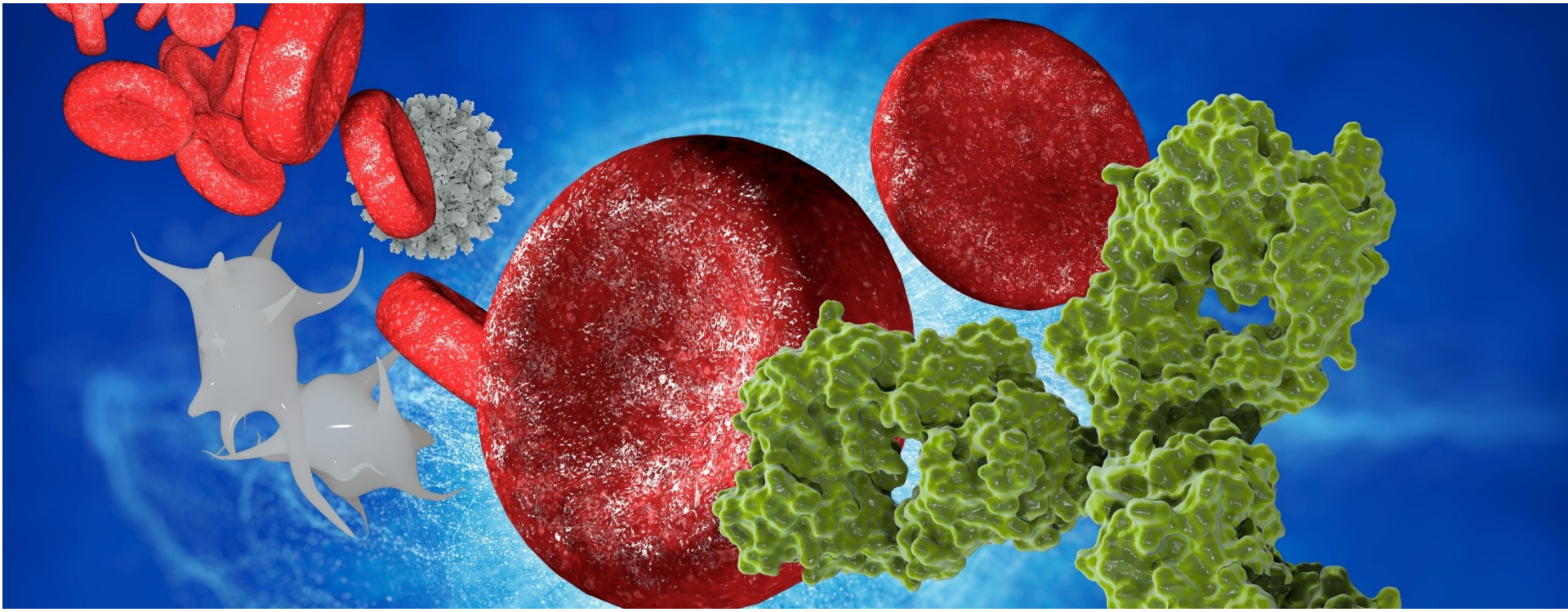


The Zinc Transporter 8 (ZnT8) Antibody

- ✓ Attacks the protein responsible for the uptake of zinc in the membrane of insulin secretory granules in beta cells
- ✓ 65% to 80% of children with recently diagnosed type 1 diabetes 20% to 40% of adults with type 1 diabetes have antibodies to ZnT8.3,4

Tyrosine Phosphatase Antibodies

- ✓ Antibodies against a physiological regulator of glucose homeostasis and energy balance
- ✓ Attack the protein that regulates cytokine-induced pancreatic beta cell apoptosis
- ✓ Positive in 50-75% of type 1 diabetics



Resources – Insulin Testing

- ✓ https://www.altmednetwork.net/leadin-home-health-tests.html
- ✓ https://www.altmednetwork.net/cgi-altmednetwork/sb/order.cgi?rd=1&storeid=*1edb71c5a90ab84f6571244739f25a6d0
- ✓ https://www.americanscreeningcorp.com/pc_product_detail.asp?key=49E38E093E16465792A14AA1A1E20088
- ✓ https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2864157/

