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The Sweet Science: Type 2 Diabetes

PRESENTED BY

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COURSE AGENDA

- Module 1 – Introduction to Type 2 Diabetes and Pathophysiology
- Module 2 – Energy Systems
- Module 3 – Correlations and Contraindications
- Module 4 – Exercise and T2D
- Module 5 – Behavior Change and Support
- Module 6 – Exercise Applications
- Module 7 – Nutrition and T2D

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Agenda

MODULE 1 - LESSON 1

- Introduction – my story
- Defining type 2 diabetes
- Etiology
- Stats
- Comorbidities
- Pathophysiology
- Exercise

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My Story

My Story by the Numbers

Date	HbA1C
August 2015	5.9
August 2016	6.3
November 2017	7.7

I just turned 40

and assumed…

Frequent urination – I'm 40

Waking up 3– 4x per night to pee (at least) – I'm 40

Hungry and thirsty ALL THE TIME! – I'm 40…?

Loss of 20% of my bodyweight in a few months … my new diet and exercise routine…?

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Criteria for Diagnosis

Normal	Below 5.7%
Prediabetes	5.7% to 6.4%
Diabetes	6.5% or above

A1C%	eAG mg/dL
7	154
8	183
9	212
10	240

https://professional.diabetes.org/diapro/glucose_calc

When I knew it was different

March 15, 2018	Fasting Blood 350 / HbA1C 12.6

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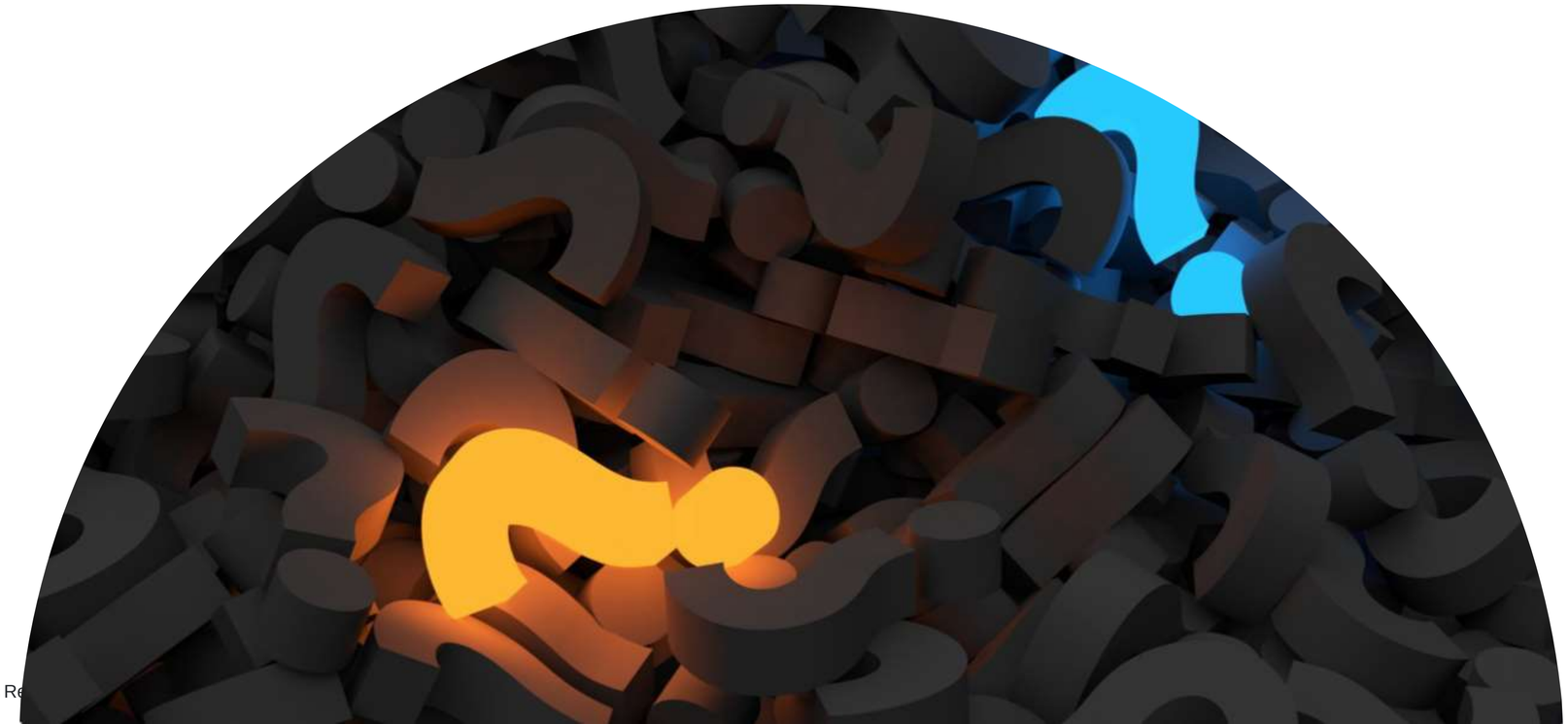
Blood glucose estimation based on A1C

https://professional.diabetes.org/diapro/glucose_calc

A1C	eAG	
%	mg/dl	mmol/l
6	126	7.0
6.5	140	7.8
7	154	8.6
7.5	169	9.4
8	183	10.1
8.5	197	10.9
9	212	11.8
9.5	226	12.6
10	240	13.4

What is Type 2 Diabetes Mellitus?



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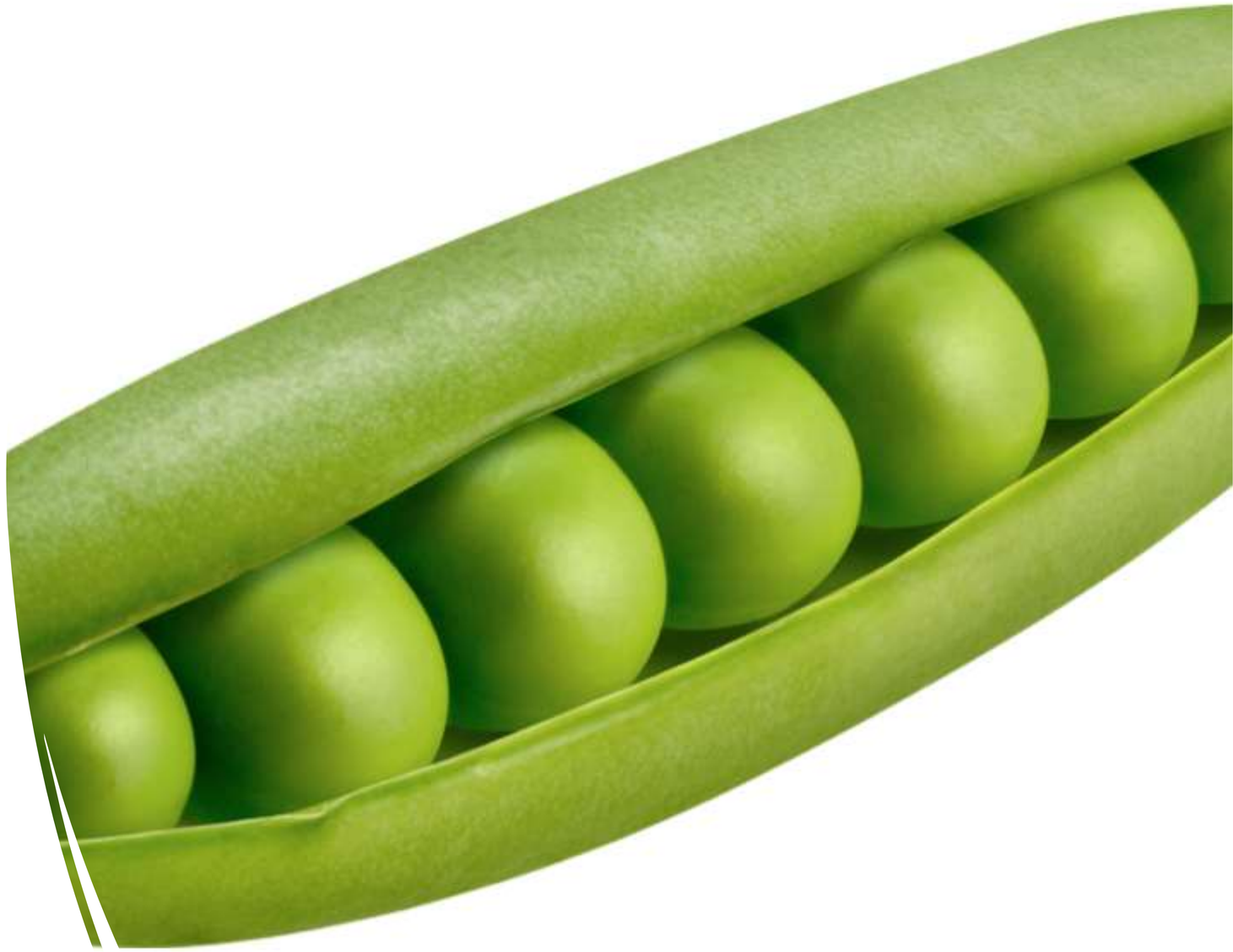
Defining Diabetes Mellitus

- Diabetes – Greek for siphon or flow through

- Mellitus –Latin meaning honeyed, sweet, or sugar

- Literal Translation – Sweet Pee (Urine)



So… How Did They Know it was Sweet?

- Physicians as early as 600 BC recorded that ants were attracted to sugar in patients' urine.

- Thomas Willis, an English physician, described diabetic urine in a 1674 journal as "wonderfully sweet as if it were imbued with honey or sugar."

What is type 2 diabetes?

- Metabolic disease
  - Carbohydrate disease
  - But, likely only after being a fat metabolism disease
- Disease of insulin resistance
- Later phases can lead to disease of beta cell “burn out” and limited or no insulin production
- Leads to vascular pathologies

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Risk Factors

- Obesity
- Fat distribution
- Dislipidemia
- Family history / Genetics
- Older Age
- Race

- CVD
- Gestational Diabetes
- Stress
- Sleep apnea
- Polycystic ovarian syndrome
- Metabolic syndrome (next page)

Metabolic Syndrome

- Waist circumference
  - Men > 40 in (>102 cm)
  - Women >35 in (>88cm)
- Hypertriglyceridemia ≥150 mg/dL
  - Low HDL-C
  - Men <40 mg/dL
  - Women <50 mg/dL
- High blood pressure ≥135 mmHg
- High fasting glucose >110 mg/dL

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LIFESTYLE / ENVIRONMENTAL RISK FACTORS

- Sedentary behaviors
- Overconsumption of sugar and “carbage”
- Overconsumption of “unhealthy” fat
- Overconsumption of (red) meat
- Smoking
- Excessive drinking
- Stress

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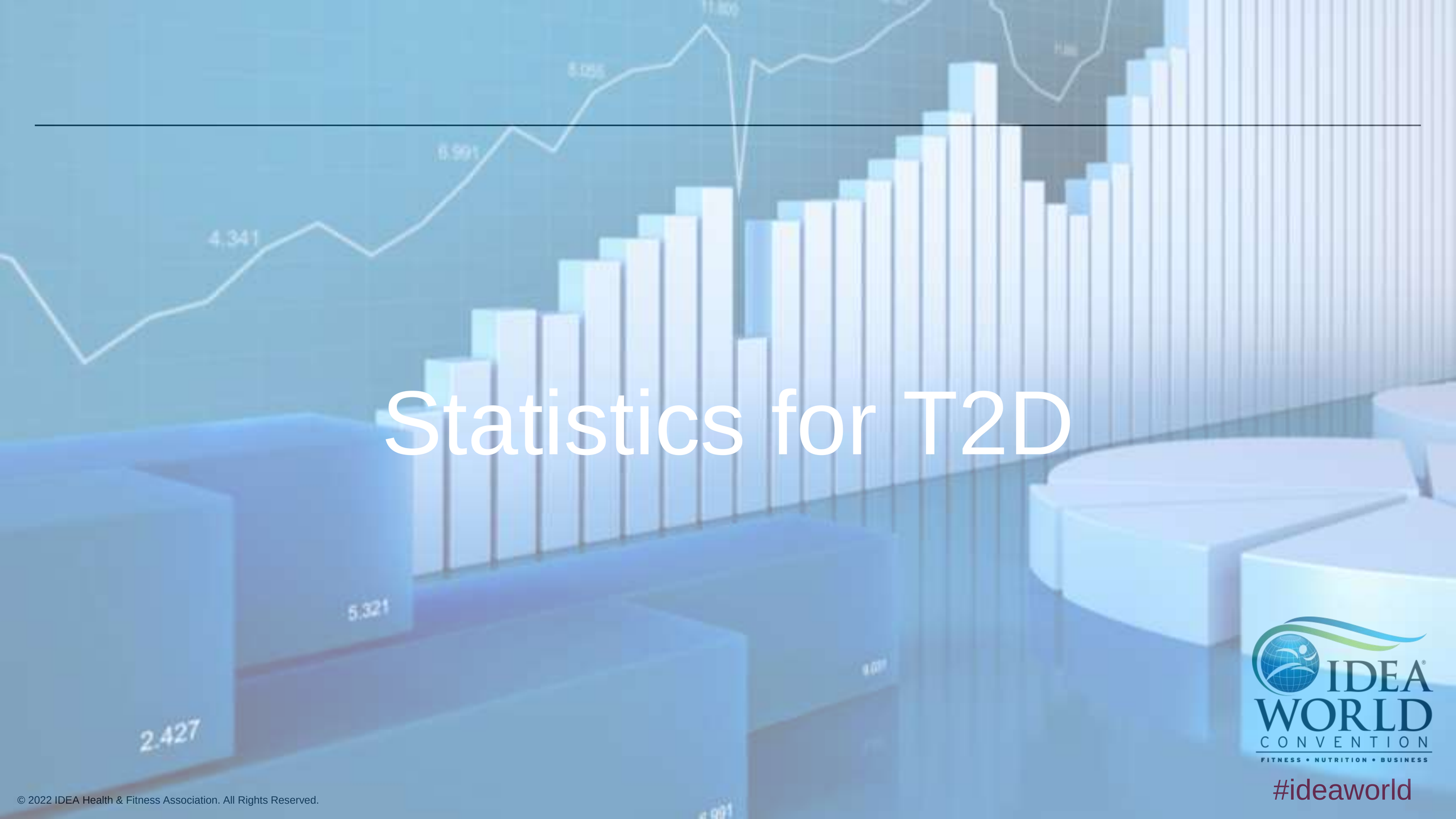
Statistics for T2D



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- Every 21 seconds someone in the US is diagnoses with diabetes (ADA)

- Type 2 diabetes is diagnosed in 1.5 million people in the US every year

- According to the National Diabetes Statistics Report (2020) put out by the Centers of Disease Control and Prevention (CDC) there are an estimated 34.2 million Americans with diabetes (approximately 1.5 in every 10) and 90-95% are type 2

- An estimated that 7.3 million of those are not aware they have diabetes

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- **Those over the age of 18 the estimates are 34.1 million which shows why type 2 diabetes is commonly known as (and previously referred to as) adult-onset diabetes**

- **From 2002-2012 the research illustrates the incidence of diabetes increasing in both type with type 1 showing a 1.8% increase and type 2 showing a 4.8% increase in young people**

/early/2018/03/20/dci18-00

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$327 billion – annual cost of diagnosed diabetes in America

$237 billion in direct medical costs

$90 billion in reduced productivity
$3.3 billion in absenteeism
$26.9 billion in reduced productivity at work (for those employed)
$2.3 billion in reduced productivity for unemployed
$37.5 billion incapable of working due to diabetes-related disability
$19.9 billion in lost productivity due to mortality

https://care.diabetesjournals.org/content/early/2018/03/20/dci18-0007

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From the previous 2012 study to this 2018 study, total diagnosed cost for diabetes rose $82 billion dollars per year

$1 in $7 healthcare dollars is spent treating diabetes and its complications

$16,752 - the average healthcare cost per diabetic patient per year
$9,601 of that is directly attributed to diabetes

https://care.diabetesjournals.org/content/early/2018/03/20/dci18-0007

First Intervention – Diet and Exercise

Dietary guidance provided by:

- Certified diabetes educator
- Registered dietician
- Physician's assistant
- Sometimes physicians

Exercise guidance provided :

- Tips
- Tricks
- Little programming or support.

None of it works if the individual is not ready to make changes

Presentation of T2D

The Three Poly's

Polydipsia – excessive thirst

Polyuria – excessive urination

Polyphagia – excessive hunger

Additional Presentations

- Blurred vision
- Unexpected / undesired weight loss or gain
- Slow wound healing
- Frequent infections
- Sweet taste in mouth upon waking
- Paresthesia
- Skin Tags

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Type 1 Diabetes

Gestational Diabetes

Diabetes Insipidus

- Autoimmune disease
- Beta cells do not produce insulin
- Insulin injections required to live
- 1922 was the first-time insulin was given to a human saving the life of a 14-year-old named Leonard Thompson.
- This won researchers J.B. Collip and John Macleod a Nobel Prize in medicine
- It also won countless others a chance to live long and productive lives

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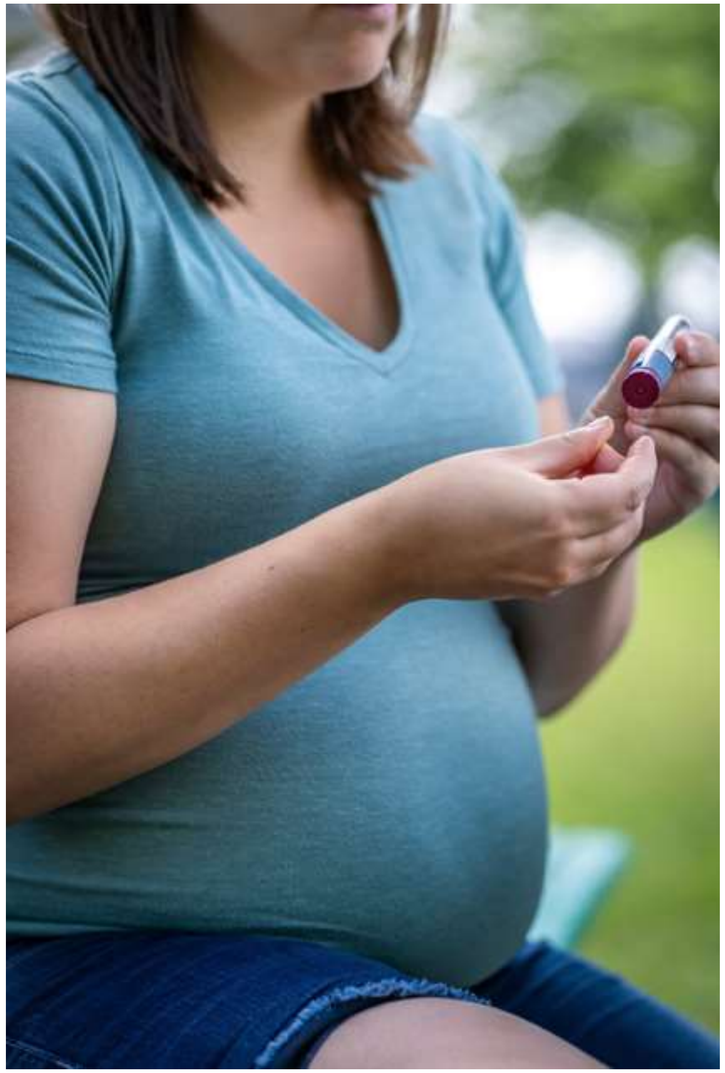

- 10% if pregnancies in the US
- The placenta makes hormones creating a buildup of blood glucose
- The mother’s pancreas cannot produce enough insulin to counteract
- Increased risk to the baby and the mother
    - Symptoms are usually chalked up to pregnancy:
        - Increased thirst
        - Increased urination
        - Hungrier and eating more than normal

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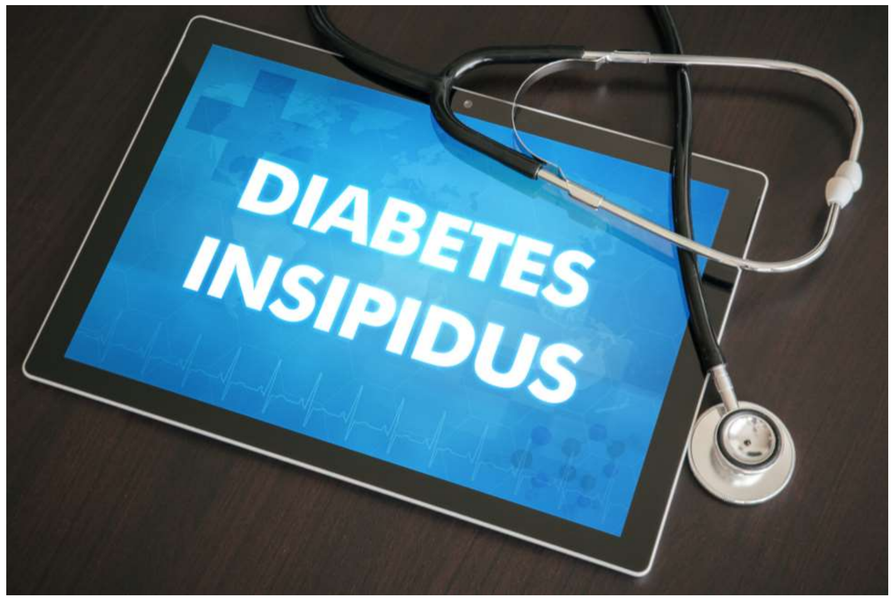
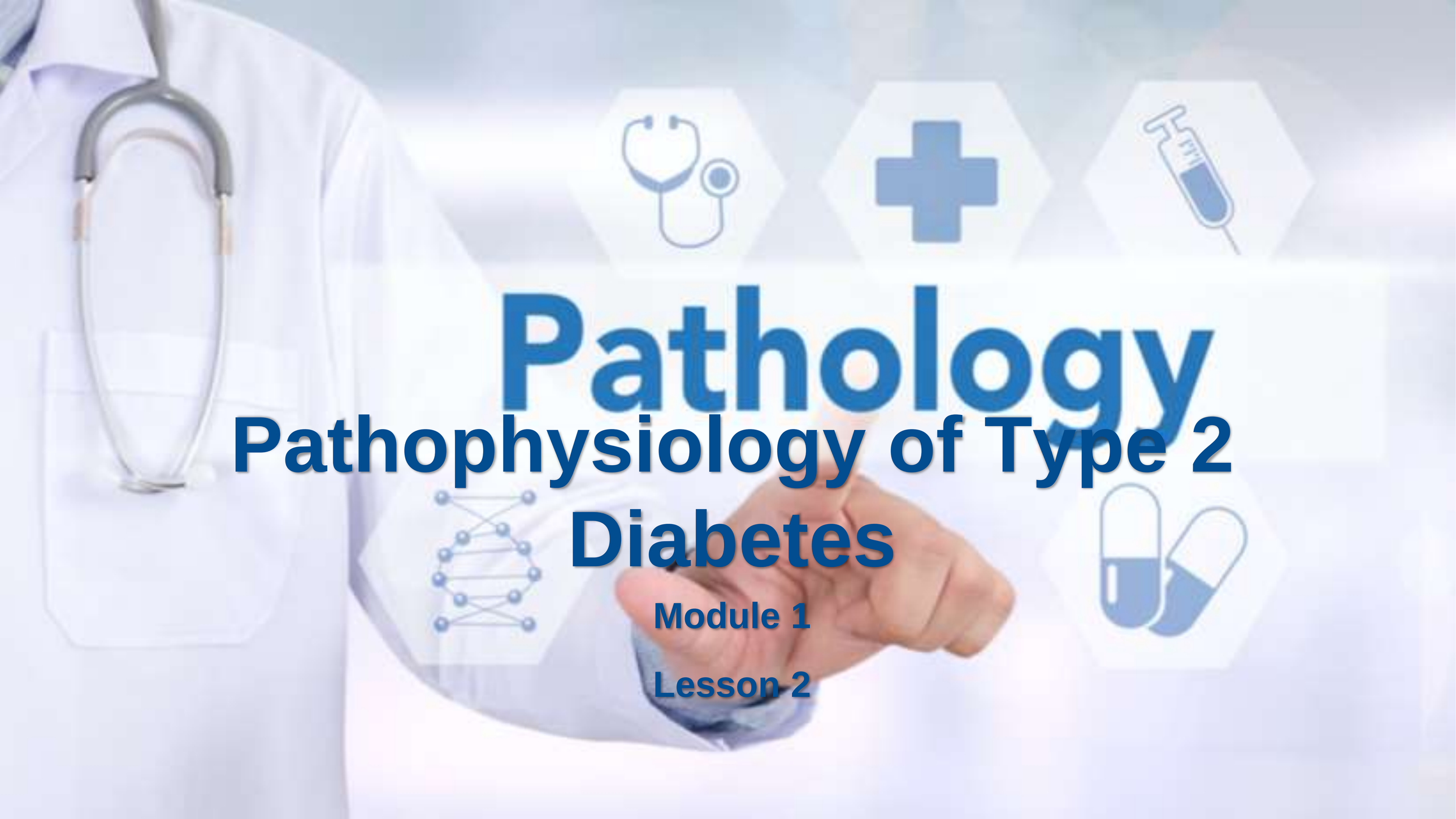


- This has nothing to do with blood glucose
- It is an issue with the fluid balancing system in the body leading to:
  - Extreme thirst
  - Polyuria day and night
  - Preference for cold drinks…

Heart to Heart Discussion on T2D



Pathophysiology of Type 2 Diabetes

Module 1

Lesson 2

Pathophysiology of Type 2 Diabetes

- Progressive Disorder
- Understanding Glucose
- Understanding Insulin
  - Insulin Resistance
  - Insulin Production
- What Causes It?

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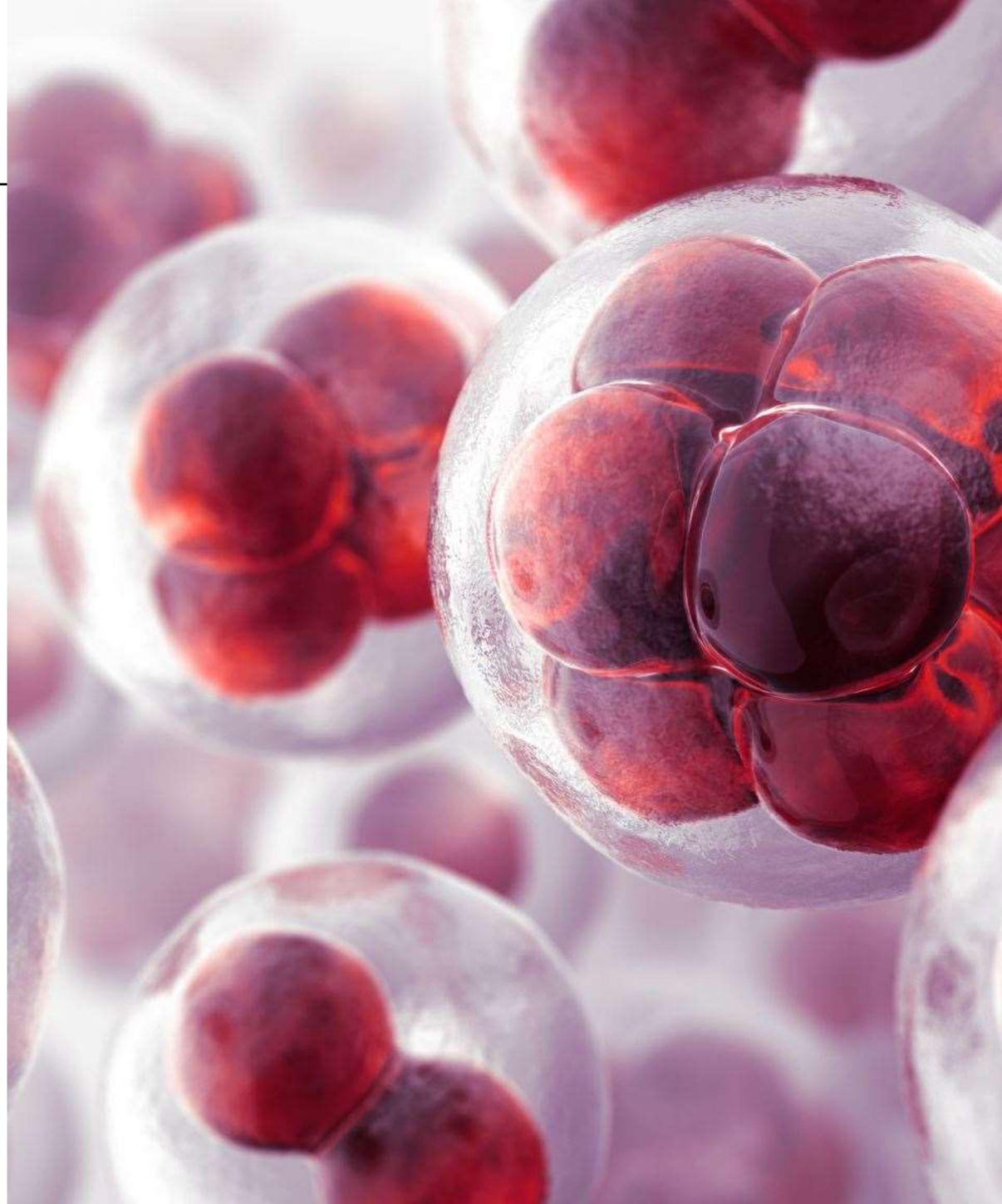
Glucose

- Food
- Metabolized
- Circulates
- Uptake and absorption (where T2D becomes an issue)

Insulin - Pancreases

- Pancreases
  - Behind the stomach and connects to the small intestine
  - Islets of Langerhans
  - Beta cell produce insulin
    - Proinsulin is produced which is broken down into
      - Insulin
      - C-peptide
  - Increases glucose uptake and glycolysis



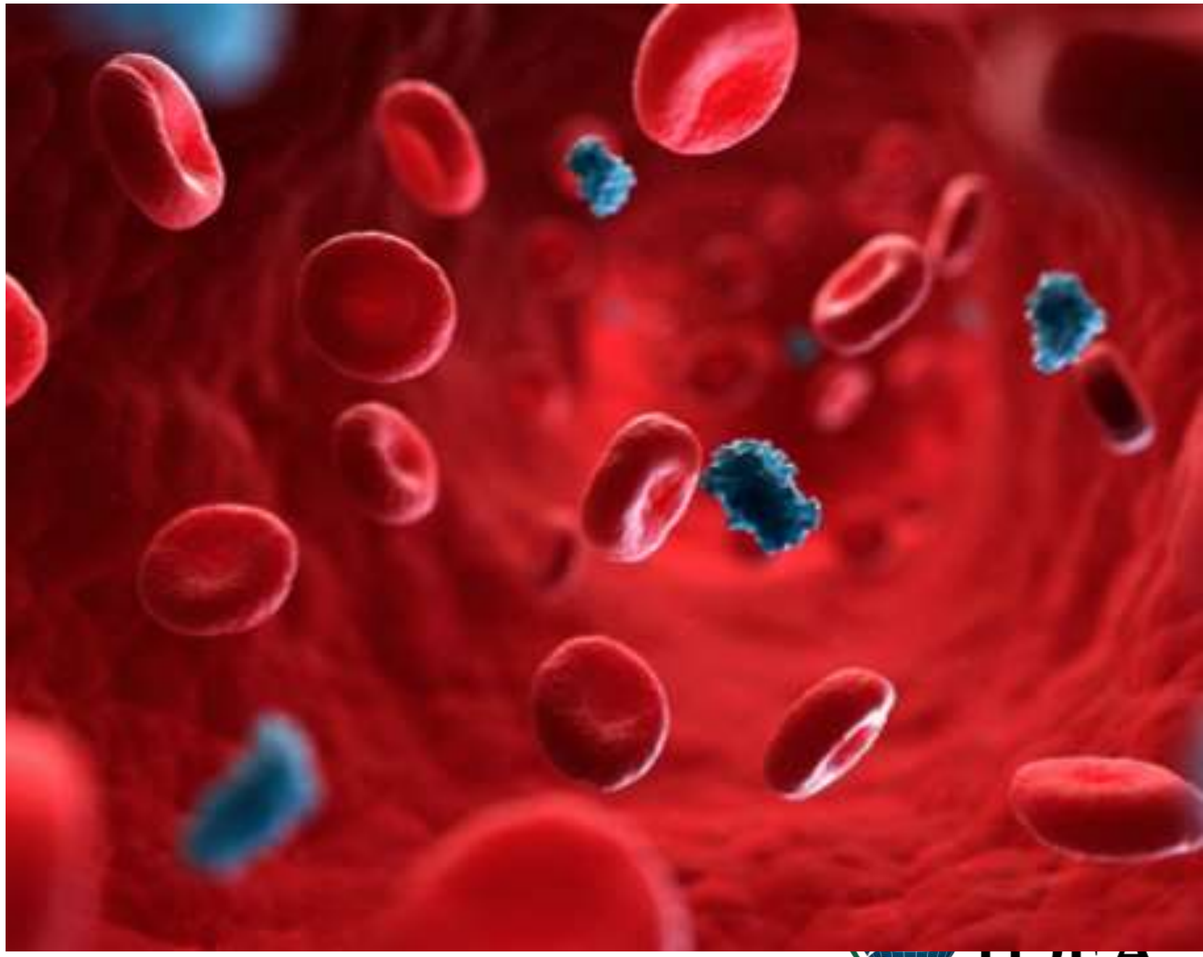
Four main tissues requiring glucose

- **Brain –** no insulin required

- **Liver** – no insulin required (but helps)
  - 5-6% of the liver's weight
  - 1.5 kg will store 100-120 grams of glycogen

- **Skeletal Muscle** – insulin required
  - 1-2% of muscle mass
  - 70 kg (150lbs) person – store ~ 400 grams of glycogen
  - Glucose uptake
  - Glycolysis

- **Adipose Tissue** – insulin increases
  - Glucose uptake
  - Glycolysis



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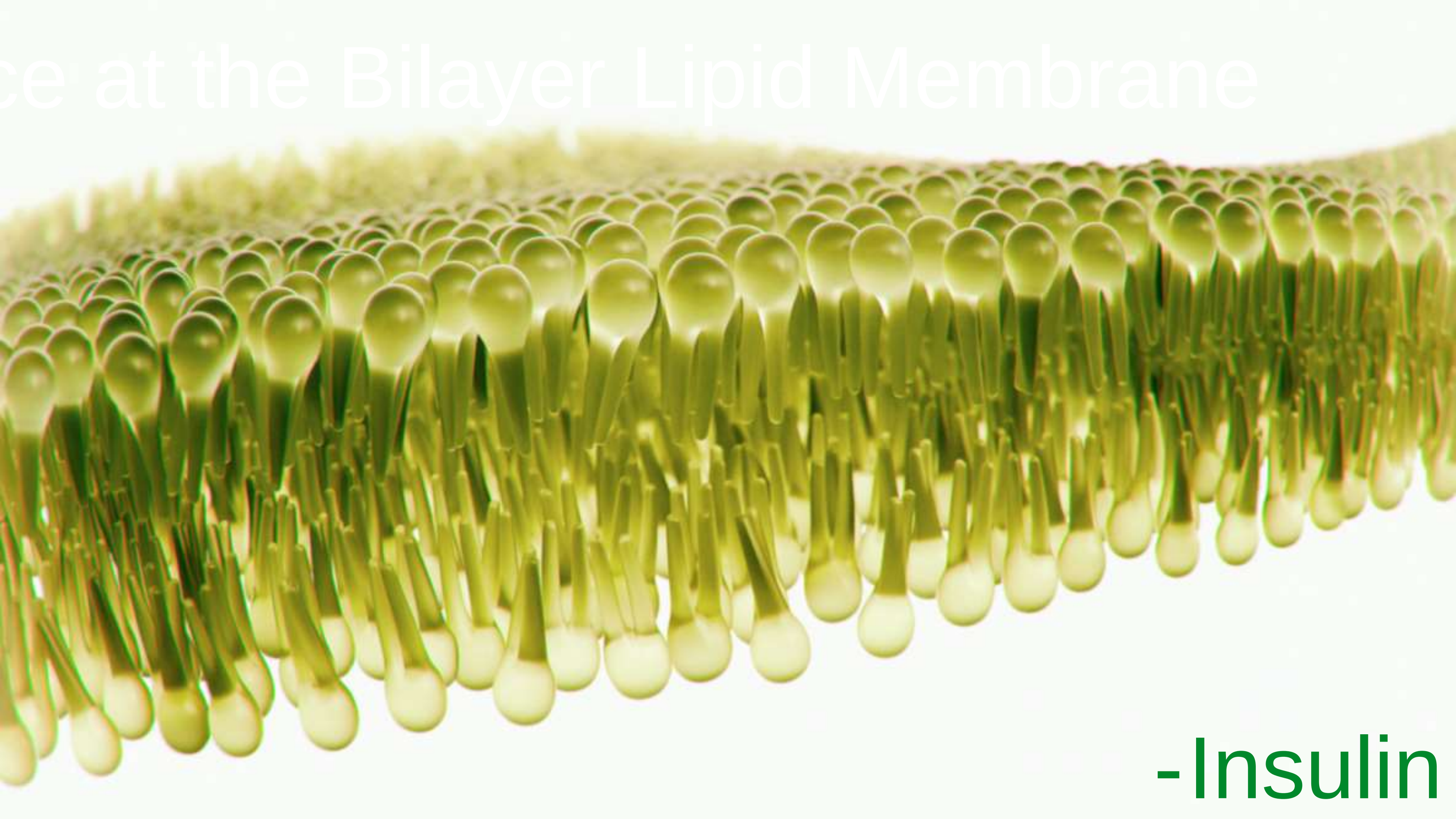
ce at the Bilayer Lipid Membrane



-Insulin

What (possibly) happens?

- Insulin resistance begins
- Beta cells produce more insulin to overcome resistance (Hyperinsulinemia or excessive insulin secretion)
- Resistance builds
- Increased hyperinsulinemia
- Resistance builds
- Beta cells fatigue, ”burn out,” and even stop producing insulin

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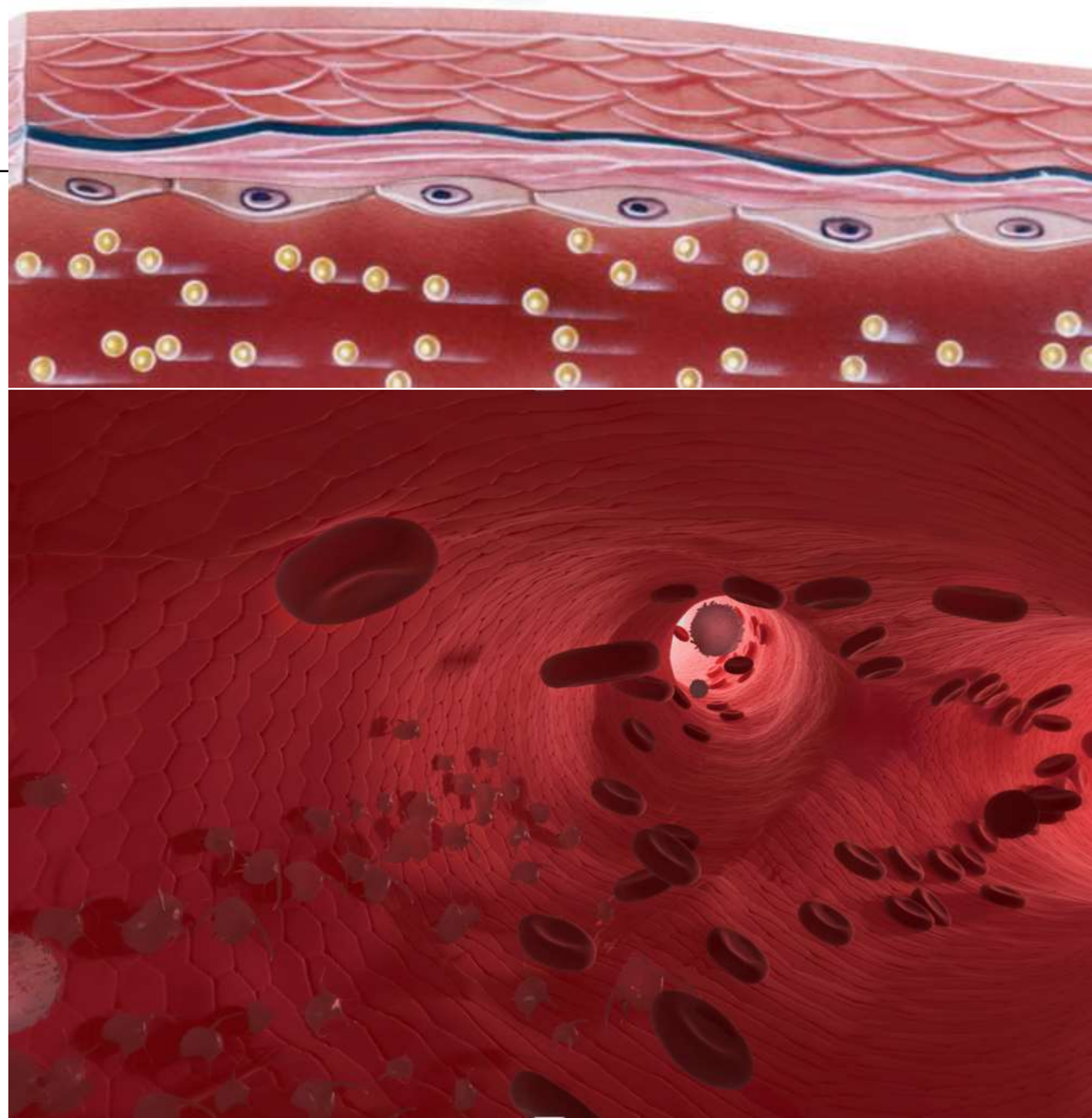
Endothelial cells line the blood vessels

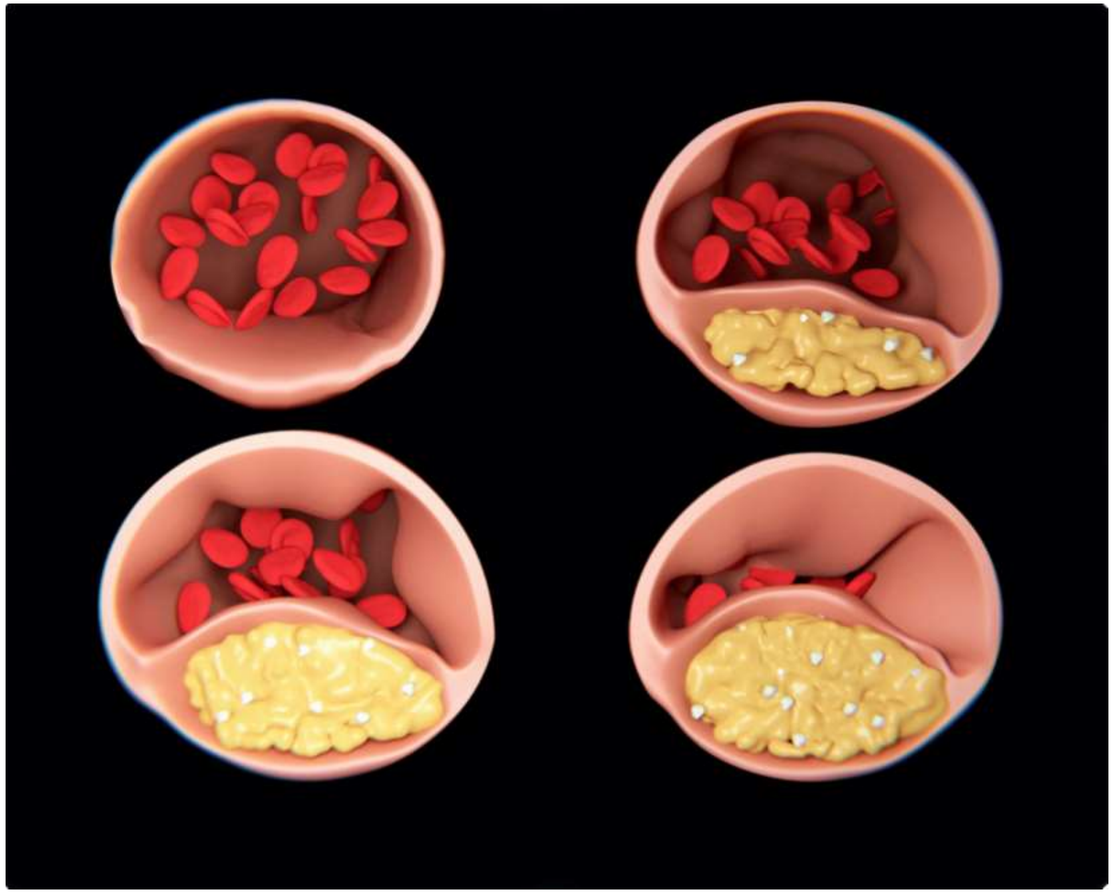
Arteriosclerosis – firming of large and medium size artery walls

Atherosclerosis – build up of plaque

Arteriolosclerosis – firming of small artery walls



Atherosclerosis



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Inflammation from Elevated Glucose Levels

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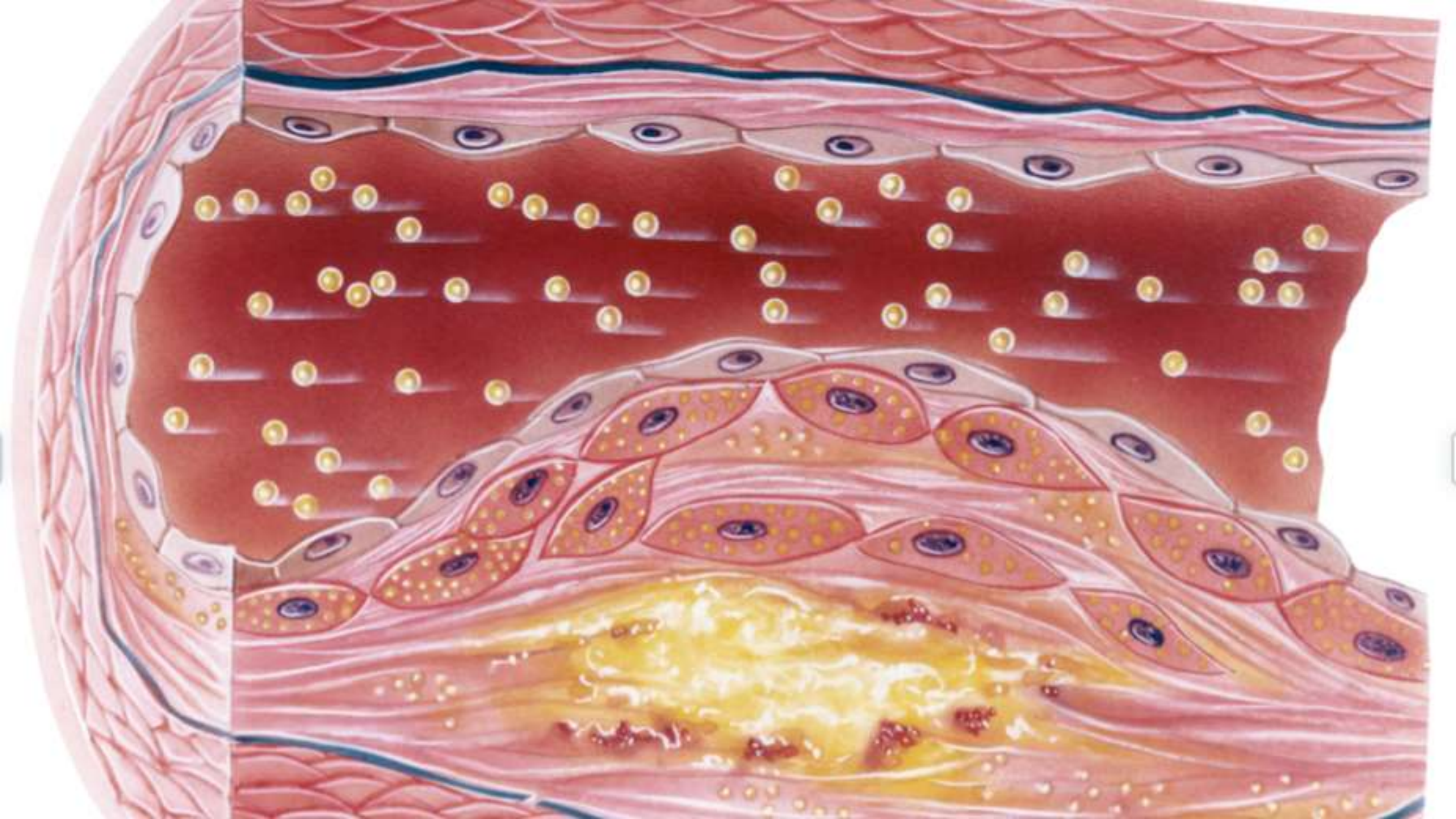

Complications for Type 2 Diabetes

Arthrosclerosis / Arteriosclerosis / Arteriolosclerosis

High blood pressure

Heart disease

Stroke

Never damage

Eye damage

Kidney damage

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Complications for Type 2 Diabetes

- Slow healing
- Hearing issues
- Skin conditions
- Sleep apnea
- Alzheimer’s disease
- Foot complications
- Ketoacidosis (rare in T2D)

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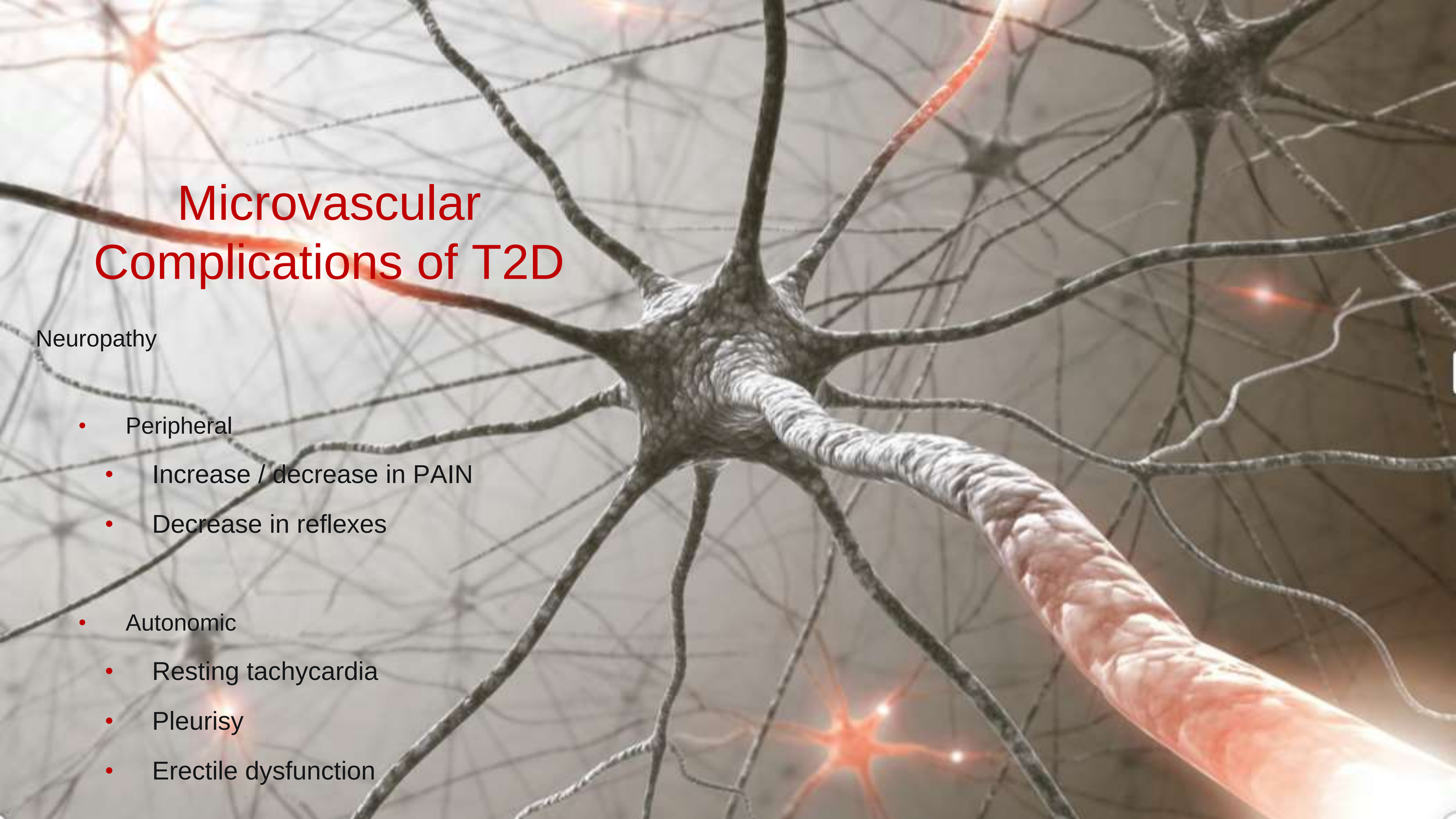
Microvascular Complications of T2D

Eyes – exam regularly

- Retinopathy
- Cotton wool spots
- Microaneurysms
- Microhemorrhages
- Macular thickening

Leading to

- Glaucoma
- Cataracts

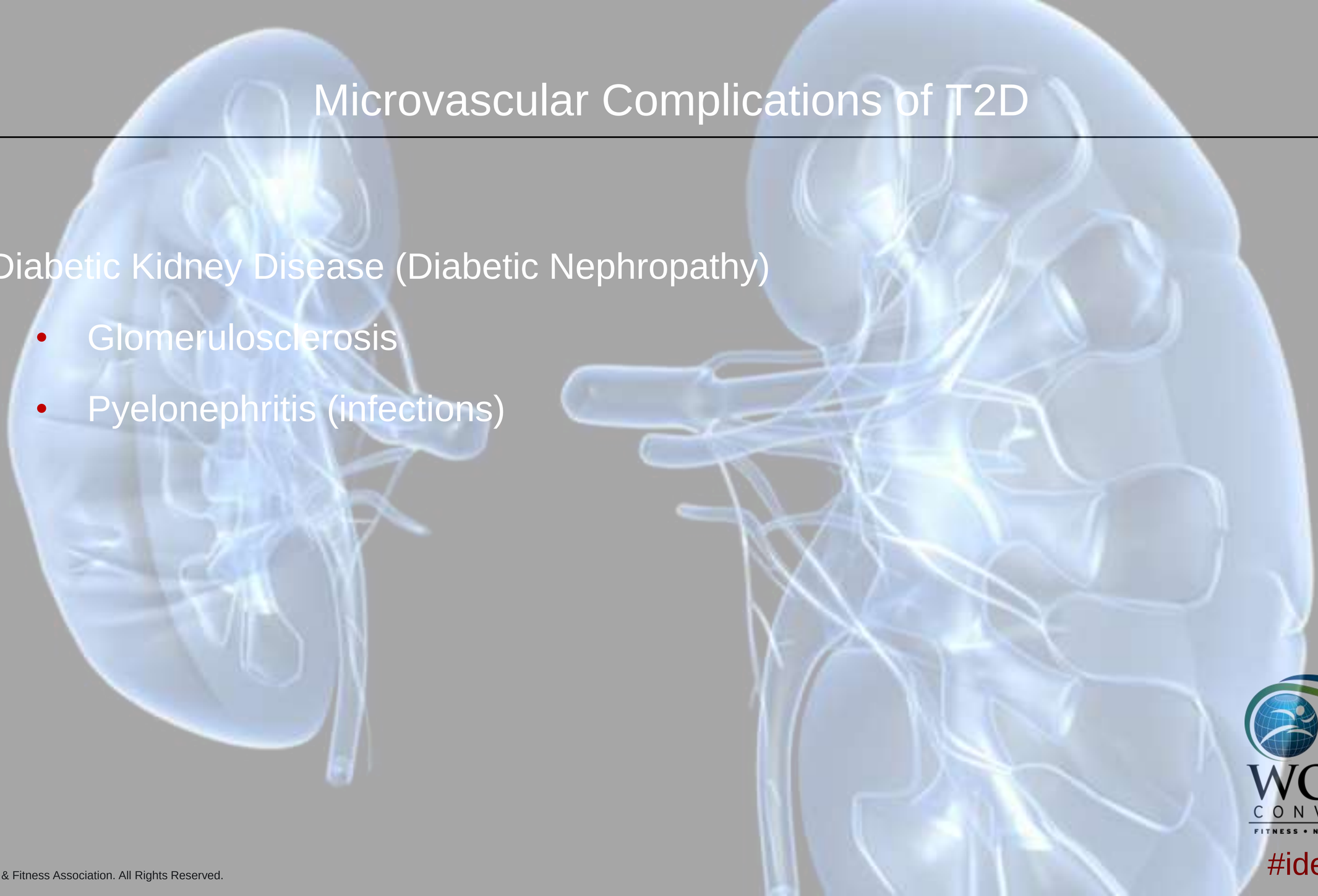


Microvascular Complications of T2D

Neuropathy

- Peripheral
  - Increase / decrease in PAIN
  - Decrease in reflexes
- Autonomic
  - Resting tachycardia
  - Pleurisy
  - Erectile dysfunction

Microvascular Complications of T2D



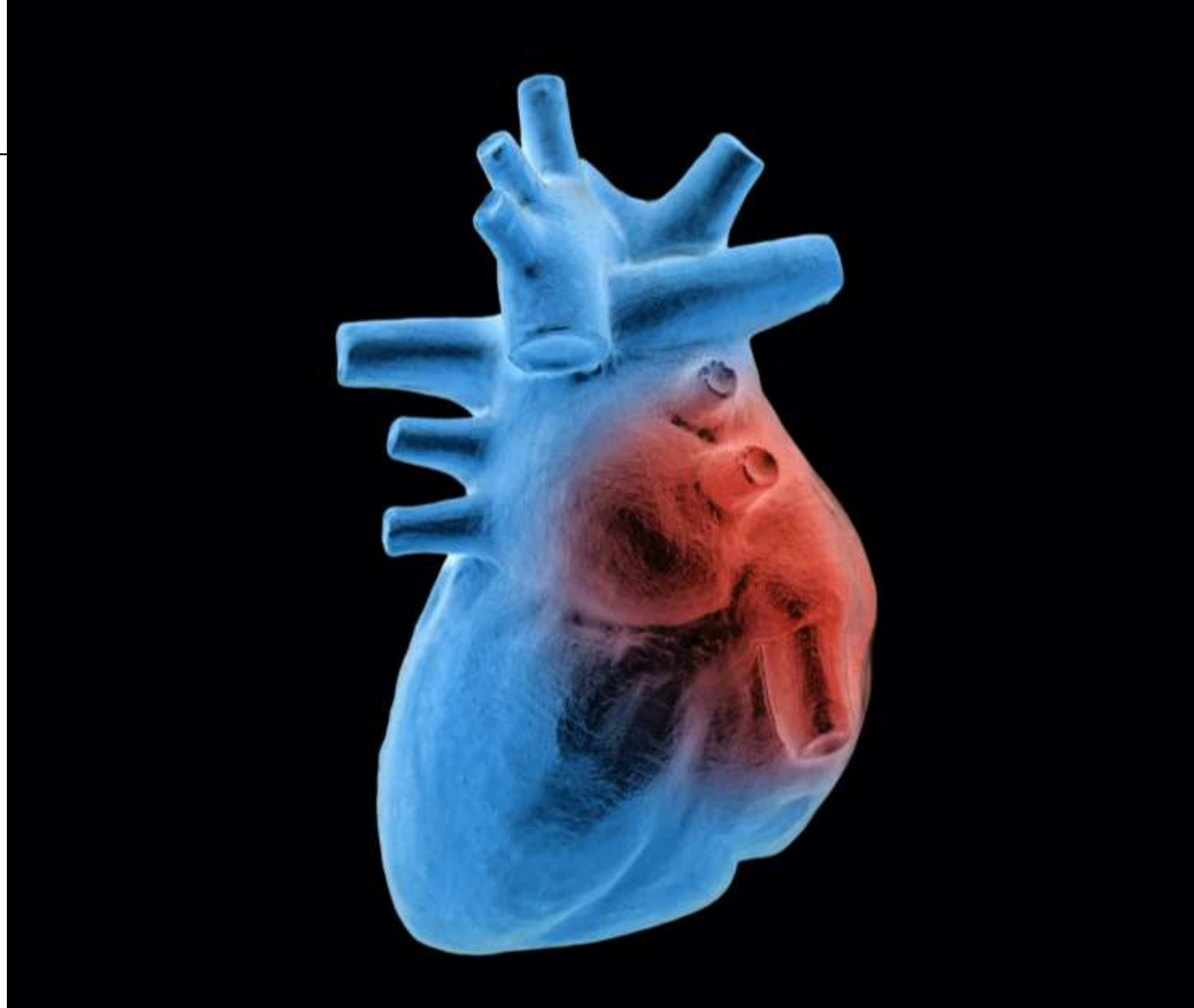
Diabetic Kidney Disease (Diabetic Nephropathy)

- Glomerulosclerosis
- Pyelonephritis (infections)

Macrovascular Complications of T2D

Heart

- Angina
- Coronary artery disease
- Myocardia infarction
- Congestive heart failure
- Dyspnea (belabored breathing)



Macrovascular Complications of T2D

Cerebrovascular

- Hemorrhages
- Cerebral infarcts (tissue death)
- Memory problems
  - Alzheimer’s disease
  - Vascular dementia

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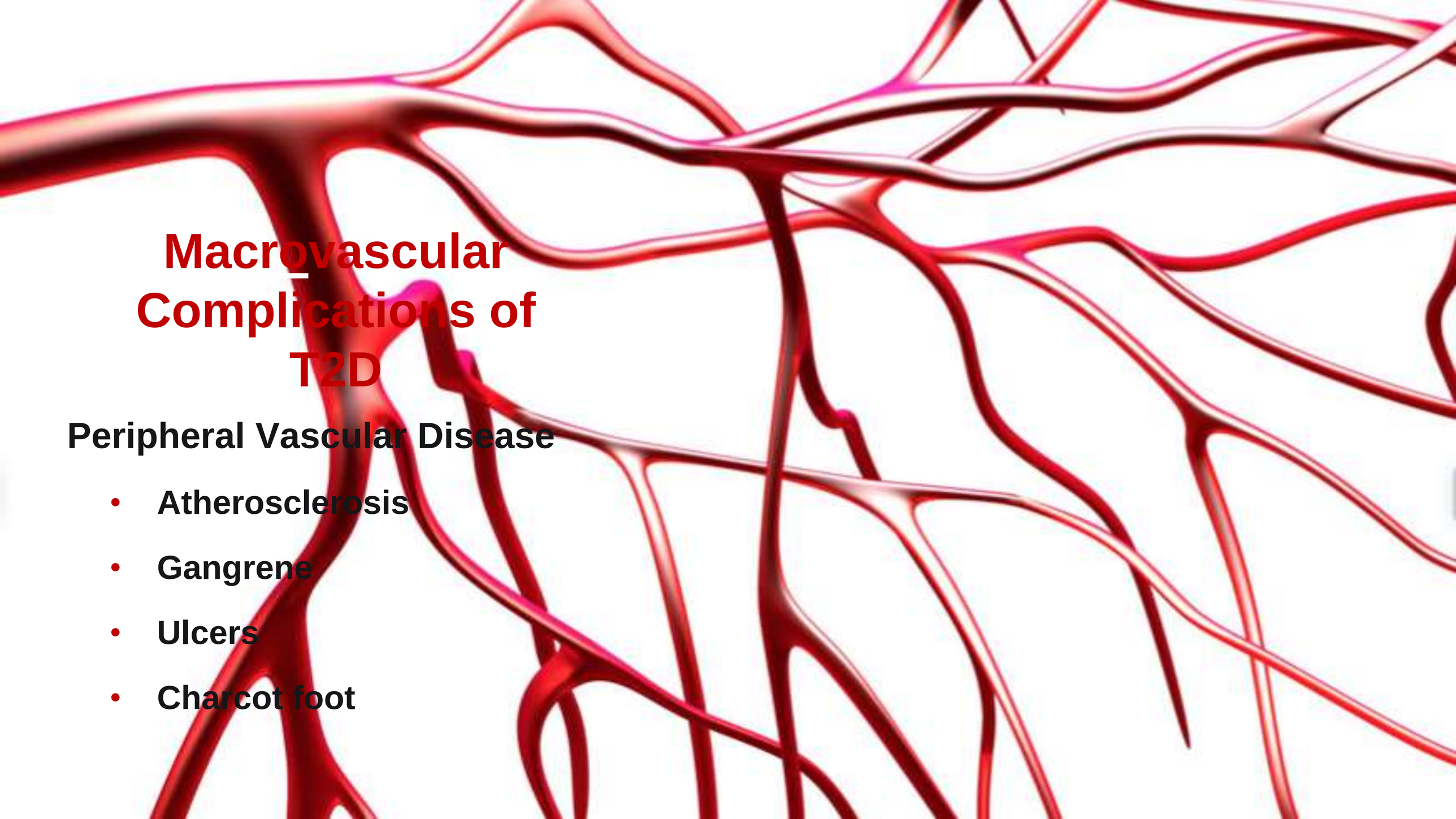

Macrovascular Complications of T2D

Peripheral Vascular Disease

- Atherosclerosis
- Gangrene
- Ulcers
- Charcot foot

Peripheral Neuropathy

- Nerves need blood
- Interferes with ability to transmit signals
- ROS
- Issues look very similar to peripheral vascular disease

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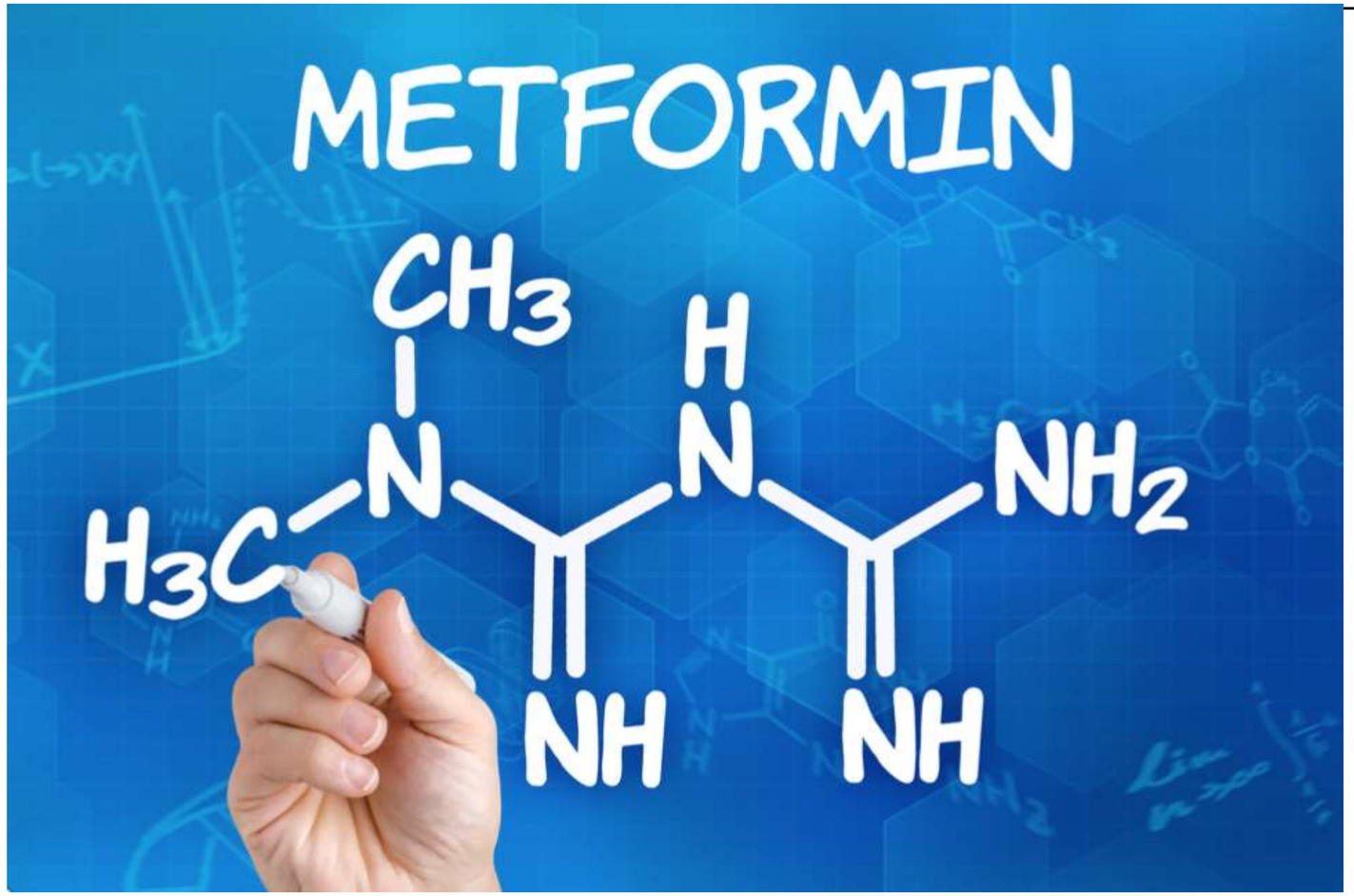
Physical Activity Guidelines and Initiatives

Physical Activity

"*If you could package physical activity into a pill, it would be the most effective drug on the market.*"

- **Dr. Ruth Petersen, Director of CDC's Division of Nutrition, Physical Activity, and Obesity**



US Diabetes Prevention Program Outcomes Study (DPPOS) show significant correlations suggesting the rate of T2DM progress is lower after lifestyle intervention compared with metformin therapy.

Diabetes Prevention Program Research Group. The 10-year cost- effectiveness of lifestyle intervention or metformin for diabetes prevention: an intent-to-treat analysis of the DPP/DPPOS. *Diabetes Care*. 2012;35(4):723–730.

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Guidelines for Physical Activity – 2018

U.S. Department of Health and Human Services. *Physical Activity Guidelines for Americans, 2nd edition*. Washington, DC: U.S. Department of Health and Human Services; 2018.

https://health.gov/sites/default/files/2019-09/Physical_Activity_Guidelines_2nd_edition.pdf

Key Guidelines for Adults – HHS 2018

Adults should *move more and sit less* throughout the day. Some physical activity is better than none. Adults who sit less and do any amount of moderate-to-vigorous physical activity gain some health benefits.

For substantial health benefits, adults should do at least

150-minutes (2 hours and 30 minutes) to 300 minutes (5 hours) a week of *moderate-intensity*, or	75 minutes (1 hour and 15 minutes) to 150 minutes (2 hours and 30 minutes) a week of *vigorous-intensity* aerobic physical activity, or	An equivalent combination of moderate- and vigorous-intensity aerobic activity.	Preferably, aerobic activity should be spread throughout the week. No more than two days to elapse between sessions.

Starting off with the Final Analysis

”In the final analysis, exercising a minimum of 150 minutes per week is as good a prescription as any and has the advantage of being a clear, attainable dose.

But there is no optimal, most beneficial dose of exercise.

People who exercise the least have the most to gain from just modest added effort, more is better, and the benefits of additional exercise gradually tail off.”

Lieberman, Daniel. Exercised (p. 294). Knopf Doubleday Publishing Group. Kindle Edition.

Key Guidelines for Adults – HHS 2018

- Additional health benefits are gained by engaging in physical activity beyond the equivalent of 300 minutes (5 hours) of moderate-intensity physical activity a week.
- Adults should also do *muscle-strengthening activities* of moderate or greater intensity and that involve all major muscle groups on 2 or more days a week, as these activities provide additional health benefits.

Resistance Training

- 2-3 days per week
- Volitional fatigue
- Non-consecutive days

Key Guidelines for Adults – HHS 2018

Light-intensity activity is non-sedentary waking behavior that requires less than 3.0 METs; examples include walking at a slow or leisurely pace (2 mph or less), cooking activities, or light household chores.

Moderate-intensity activity requires 3.0 to less than 6.0 METs; examples include walking briskly (2.5 to 4 mph), playing doubles tennis, or raking the yard

Vigorous-intensity activity requires 6.0 or more METs; examples include jogging, running, carrying heavy groceries or other loads upstairs, shoveling snow, or participating in a strenuous fitness class. Many adults do no vigorous-intensity physical activity

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General Physical Activities Defined by Level of Intensity

The following is in accordance with CDC and ACSM guidelines.

Moderate activity[+] 3.0 to 6.0 METs* (3.5 to 7 kcal/min)	**Vigorous activity**[+] Greater than 6.0 METs* (more than 7 kcal/min)
Walking at a moderate or brisk pace of 3 to 4.5 mph on a level surface inside or outside, such as • Walking to class, work, or the store; • Walking for pleasure; • Walking the dog; or • Walking as a break from work. Walking downstairs or down a hill Racewalking—less than 5 mph Using crutches Hiking Roller skating or in-line skating at a leisurely pace	Racewalking and aerobic walking—5 mph or faster Jogging or running Wheeling your wheelchair Walking and climbing briskly up a hill Backpacking Mountain climbing, rock climbing, rapelling Roller skating or in-line skating at a brisk pace
Bicycling 5 to 9 mph, level terrain, or with few hills Stationary bicycling—using moderate effort	Bicycling more than 10 mph or bicycling on steep uphill terrain Stationary bicycling—using vigorous effort
Aerobic dancing—high impact Water aerobics	Aerobic dancing—high impact Step aerobics Water jogging Teaching an aerobic dance class

Active People, Healthy Nation - CDC, 2017

The goal of Active People, Healthy Nation^{SM} to help 27 million Americans become more physically active

One of every two Americans lives with a chronic disease

Only half of adults get the needed PA needed to reduce and prevent chronic disease

$117 billion in annual health care costs are associated with inadequate physical activity

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Active People, Healthy Nation - CDC, 2017

Only **1 in 5** adults and **1 in 5** high school students fully meet physical activity guidelines for aerobic and muscle- strengthening activities.

About **31 million** adults aged 50 or older are inactive, meaning they get no physical activity beyond that of daily living.

Inactivity contributes to **1 in 10** premature deaths.

Many Americans do not have safe or convenient places to be active.

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Physical Activity and T2D

Things To Know

- Control groups (CON) are only in RCTs. Otherwise, they are comparison groups. Note in advance that “CON” will be used throughout for both.

Physical Activity – Kriska et al., 2020

Kriska, A. M., Rockette-Wagner, B., Edelstein, S. L., Bray, G. A., Delahanty, L. M., Hoskin, M. A., . . . Group, T. D. (2020). The Impact of Physical Activity (PA) on the Prevention of Type 2 Diabetes; Evidence and Lessons Learned from the Diabetes Prevention Program (DPP), a Long-Standing Clinical Trial Incorporating Subjective and Objective Activity Measures. https://doi:10.2337/figshare.13103333.v1

- Diabetes Prevention Program (DPP)
  - 1996-2001 with an 11–13-year follow-up
  - 27 facilities and n=3,234
  - RCT
  - Physical Activity vs Metformin better in prevention/delaying T2D in high-risk adults.

Physical Activity – Kriska et al., 2020

- There was a 6% decrease in diabetes incidence per 6 MET-h/week increase in time-dependent PA vs the entire cohort (metformin & control)
  - 4 (days) x 3 (METs) x 0.5 (hours) = 6 MET-h/week
- PA was inversely related to the development of diabetes over the long term and remain significant even when adjusted for weight change
- Based on the findings of this study, researchers urge health care professionals to look *beyond their high-risk patient's weight* and consider his or her *habitual PA levels* when discussing life- style strategies to prevent progression to type 2 diabetes.

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Physical Activity – Wahid et al., 2016

Wahid, A., Manek, N., Nichols, M., Kelly, P., Foster, C., Webster, P., Kaur, A., Friedemann Smith, C., Wilkins, E., Rayner, M., Roberts, N., & Scarborough, P. (2016). Quantifying the Association Between Physical Activity and Cardiovascular Disease and Diabetes: A Systematic Review and Meta-Analysis. *Journal of the American Heart Association*, *5*(9), e002495. https://doi.org/10.1161/JAHA.115.002495

- Data pooled 1981-2014
- 36 studies
- N=3,439,874

Physical Activity – Wahid et al., 2016

- Increase in 11.25 MET h/week for an inactive individual
- Inactive to 150min/wk of moderate intensity activity
  - 150 min x 4.5 MET = 675 MET-m/wk / 60mins = 11.25 MET-h/week

- Lower risk of CVD mortality by 23%
- Lower risk of CVD incidence by 17%
- Lower risk of T2DM incidence by 26%
  - *Independent of bodyweight*

- The greatest gain in health is associated with going from inactivity to small amounts of PA

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Short Bouts of Stair Climbing – Honda et al., 2016

Honda, H., Igaki, M., Hatanaka, Y., Komatsu, M., Tanaka, S., Miki, T., Suzuki, T., Takaishi, T., & Hayashi, T. (2016). Stair climbing/descending exercise for a short time decreases blood glucose levels after a meal in people with type 2 diabetes. *BMJ open diabetes research & care*, *4*(1), e000232. https://doi.org/10.1136/bmjdrc-2016-000232

- N=13 men and 3 women w/ T2D under age 75
- Stair climbing and descending - time-saving and non-strenuous high-intensity exercise (HIE)

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Short Bouts of Stair Climbing – Honda et al., 2016

- On separate days 1-2 weeks apart
- Ate a meal and sat for 180 mins

OR

- Ate a meal and climbed up and down one flight of stairs for 3 mins at the 60 min and 120 min marks
  - Stair climbing rate of 80– 110 steps/min followed by walking down slowly to the first floor at a free step rate.
- Glucose levels at 60mins elicit no change
- Glucose levels 150mins after meal 18% lower

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Short Bouts of Stair Climbing – Honda et al., 2016

- The heart rate and blood lactate levels indicated that the actual intensity of stair climbing exercise was ‘hard’
- RPE to stair climbing was considered moderate
- This may indicate an excellent intensity to perception of difficulty ratio that may be useful, low volume, non-strenuous and timesaving form of physical exercise.

Other Exercise Options?

- Resistance training
- Mindbody exercises
- HIIT
- MICT
- LICT
- Core
- Balance training

What about starting exercise?

What about starting exercise?

- Let your PCP or endocrinologist know
- Do not change your medication or dosage
- Some medications and insulin can lead to drop in BG while exercising
  - Be prepared with a non-tempting high glycemic snack

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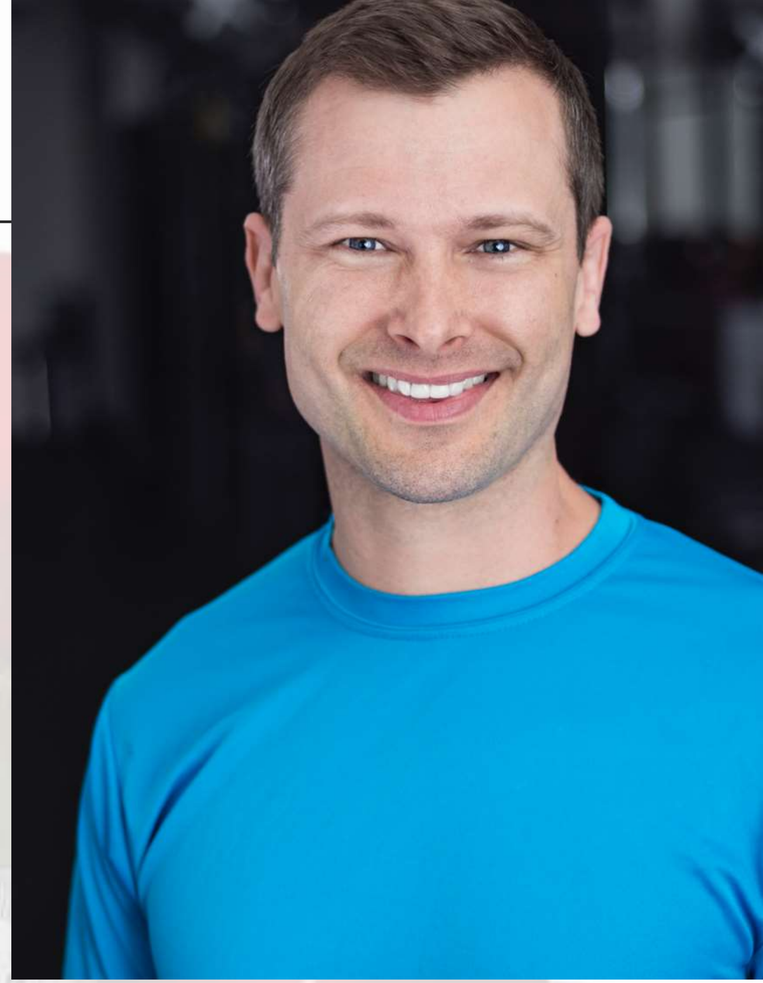
Thank You



Q&A?

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