

# Diabetes Mellitus

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# Course Objectives

- Define/Characterize Diabetes Mellitus (DM)
- Review the incidence of DM
- Examine carbohydrate/glucose digestion, absorption & metabolism
- Analyze the hormones/chemicals involved in glucose digestion, absorption & metabolism
- Examine insulin functions in detail

# Course Objectives

- Review DM risk factors
- Consider possible causes of DM
- Examine DM pathology by DM type
- List and study Sx of DM & Tx complications
- Examine DM complications
- Review DM Tx Modalities

# Definition

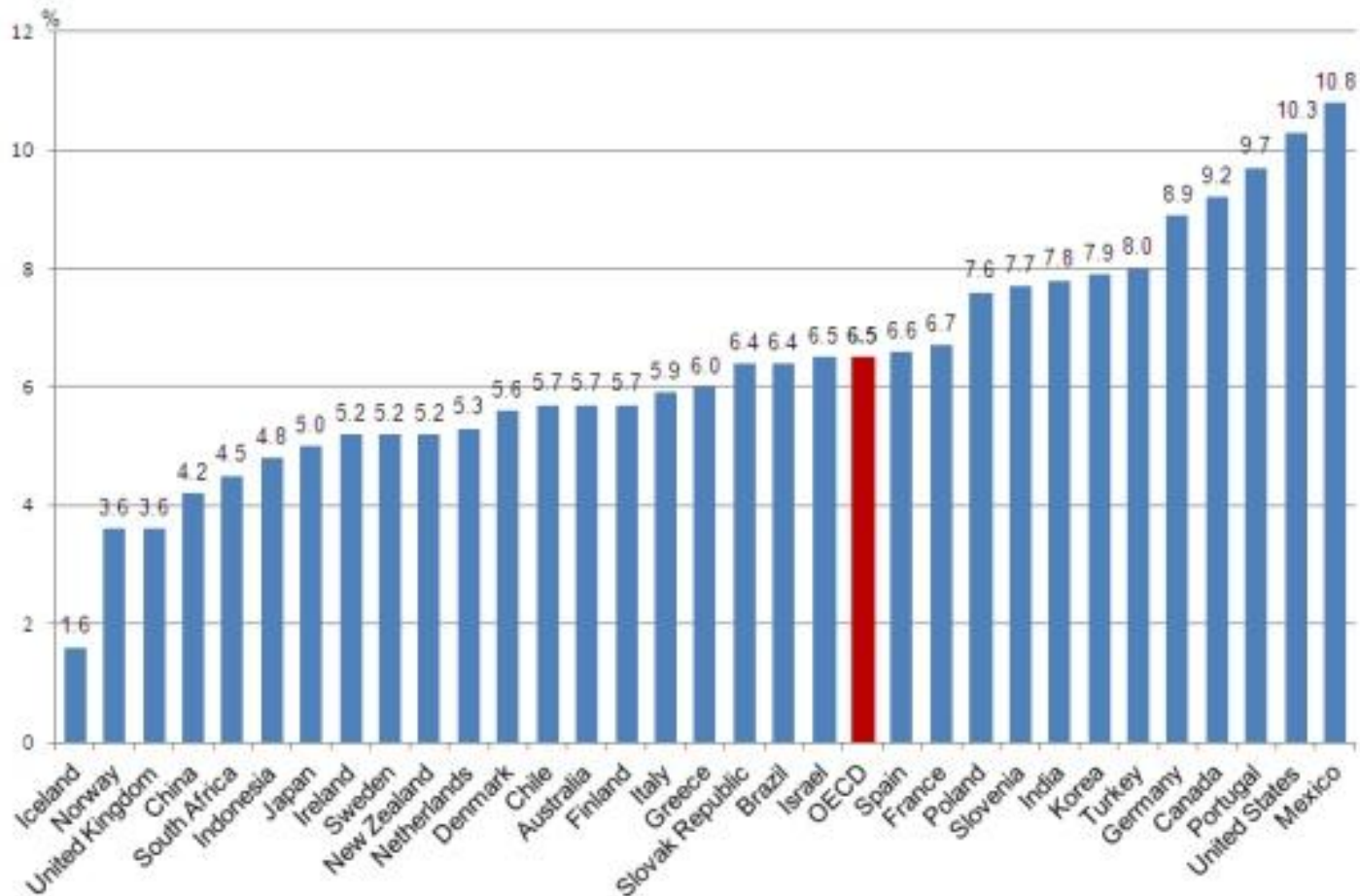
- A complex group of metabolic diseases in which a person has elevated blood sugar concentration (hyperglycemia of  $\geq 126$  mg/dl or  $\text{HbA}_{1c} \geq 6.5$ )

# Who, When, What (3)



# STATISTICS

# Prevalence of Diabetes by Country

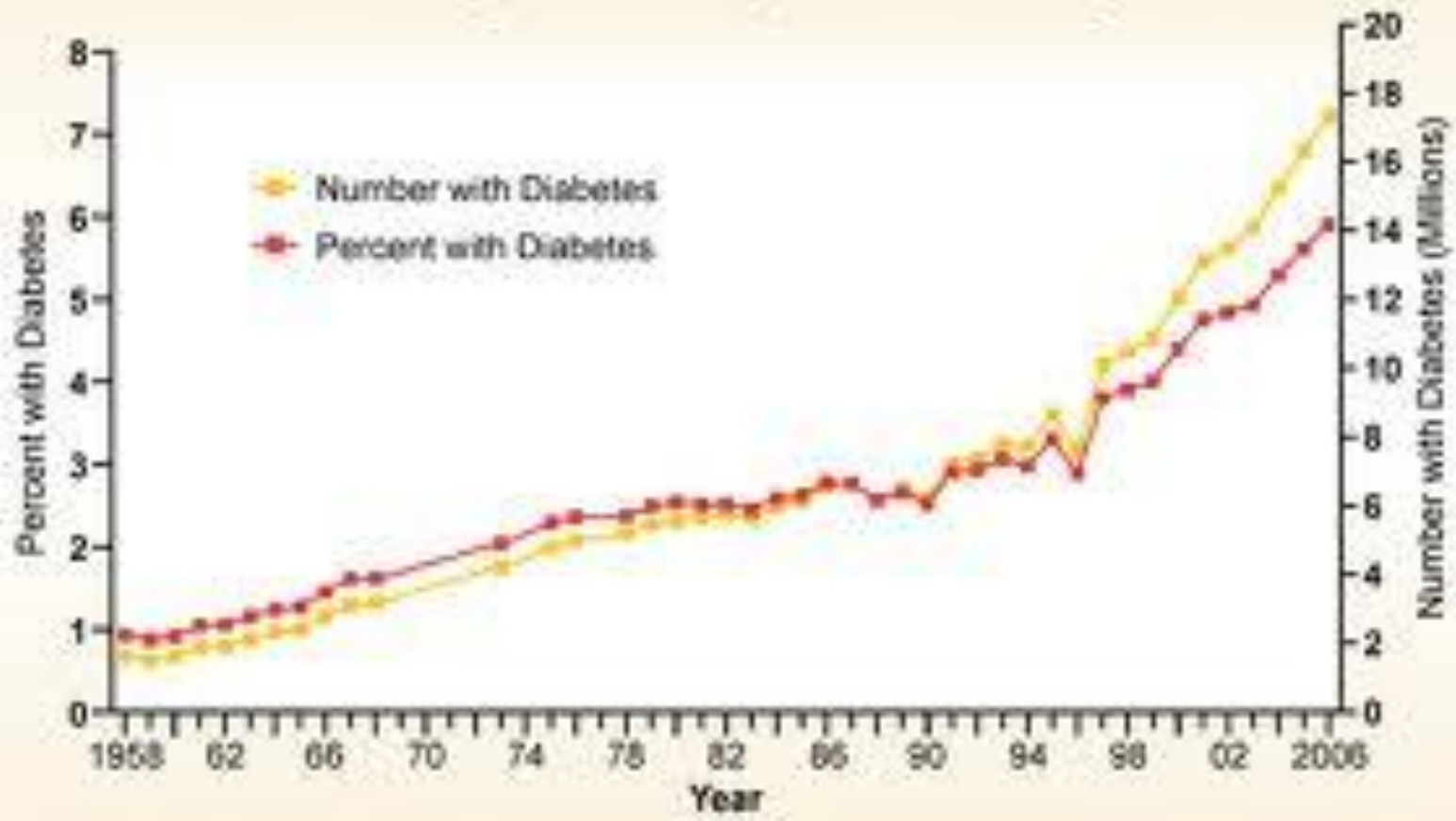


# Epidemiology - World

- In 2011, 366 million had DM.  
Estimated that  $\frac{1}{2}$  (183 million) are undiagnosed
- DM caused 4.6 million deaths in 2011
- Prediction: by 2030, 552 million will have DM.



### Number and Percentage of U.S. Population with Diagnosed Diabetes



# Epidemiology – U.S. <sup>(1)</sup>

- 25.8 million = 8.3% of population (2011)
- 18.8 million diagnosed; 7.0 million undiagnosed (2011)
- Prediabetes affects 35% of adults 20+

# Epidemiology – U.S. (2)

- Age (2011)
  - 215,000 < 20 years (2.6%) (about 1 in 400)
  - 10.9 million > 65 (26.9%) (Types 1 & 2)
- Gender
  - Males: 13.0 million or 11.8% of pop. age 20 or older
  - Females: 12.6 million or 10.8% of pop. age 20 or older

# Epidemiology – U.S. <sup>(4)</sup>

- Morbidity/Mortality – 2007
  - 71,382 deaths (6<sup>th</sup> leading cause of death)
  - Contributed to 160,022 deaths
- Overall death risk  $\cong$  2x of those without DM
- Life expectancy shorted by 5 - 10 years
- Cost (2007): Total - \$174 billion [\$116 billion medical direct; \$58 billion indirect (disability, work loss, premature mortality)]

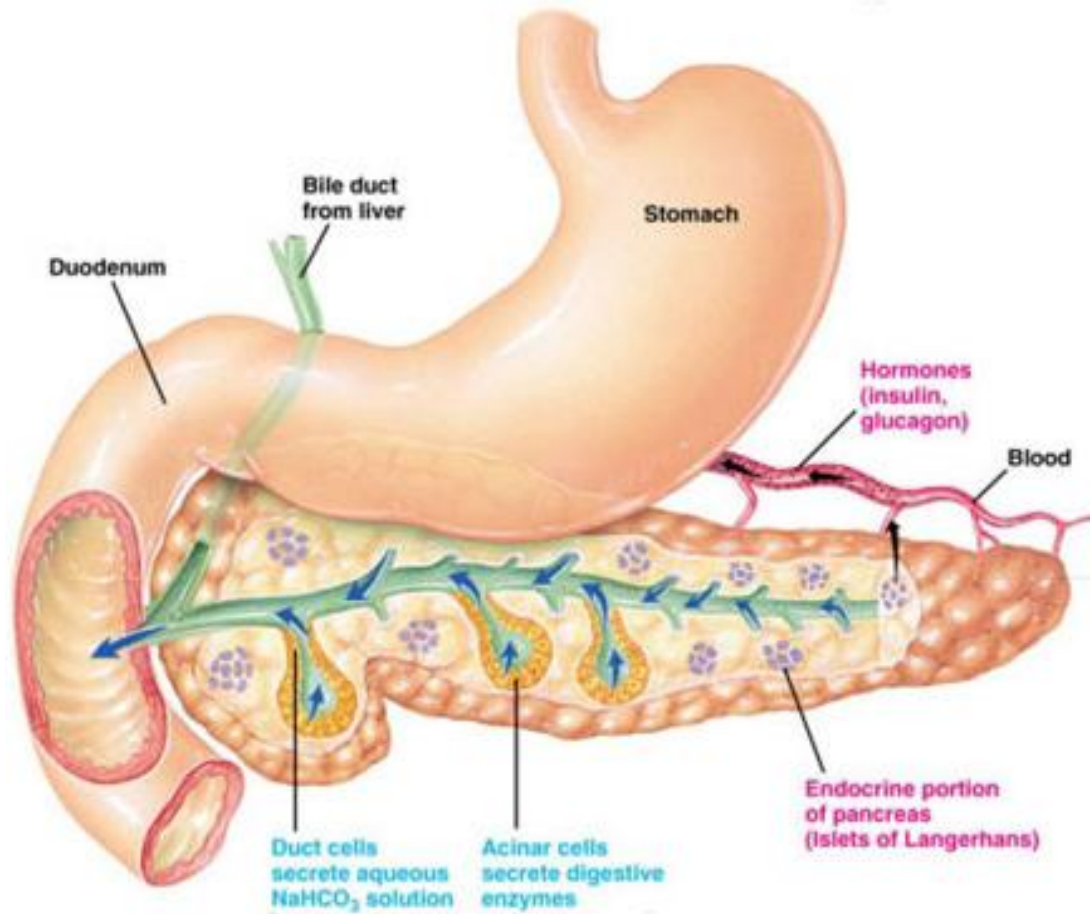
# Epidemiology – U.S. (5)

- DM Complications (2005-2008) Leading cause
  - new blindness 4.2 million (28.5%) with DM 39+ had diabetic retinopathy
  - nontraumatic lower-limb amputation (> 60%)
  - kidney failure (44% of new cases in 2008 & any given year > 50,000 DM on dialysis or transplant)
  - 2 – 12X the risk for heart disease
  - 2 – 4X the risk for stroke

# Epidemiology – U.S. (6)

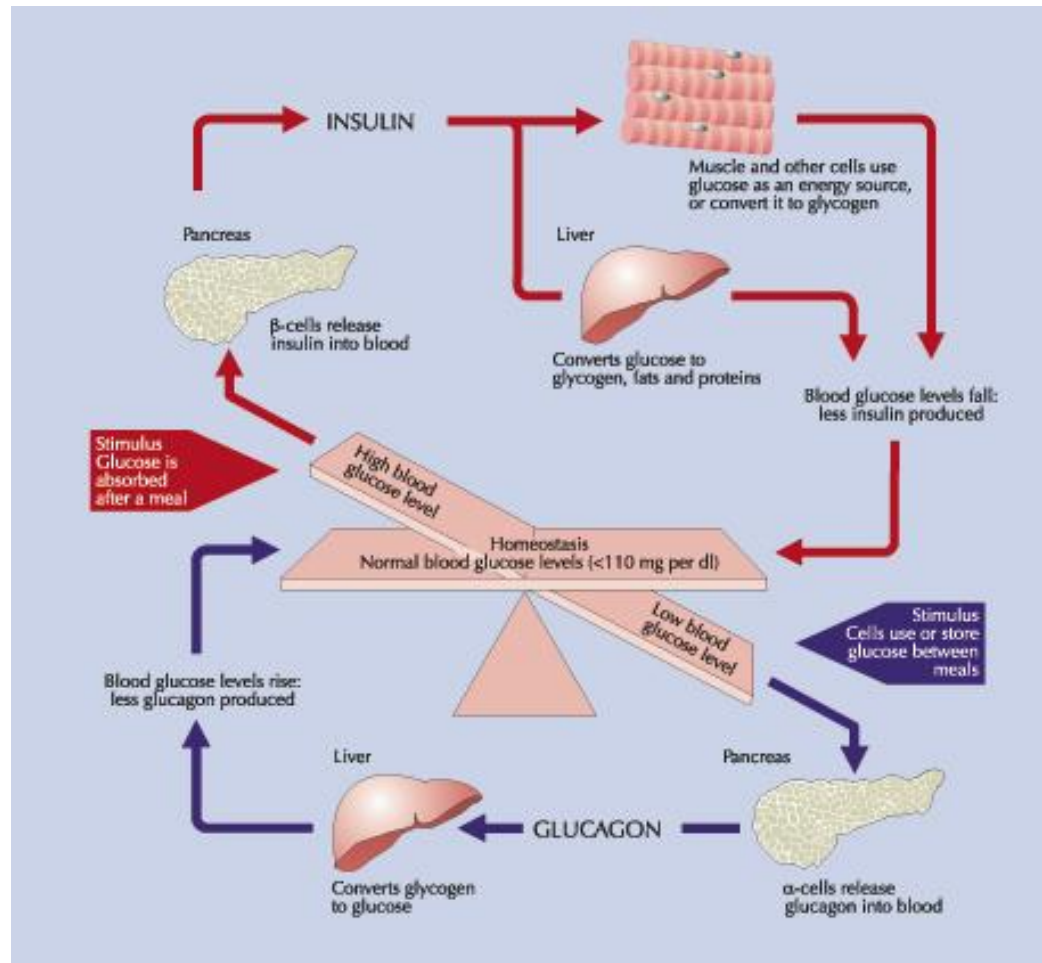
- Developmental Disabilities & DM: No statistics were found but source after source state that the chance of diabetes prevalence, causative conditions, complications and Tx difficulty is higher in those with DD.

# **BLOOD SUGAR ANATOMY & PHYSIOLOGY**





# Balancing [Blood Sugar]



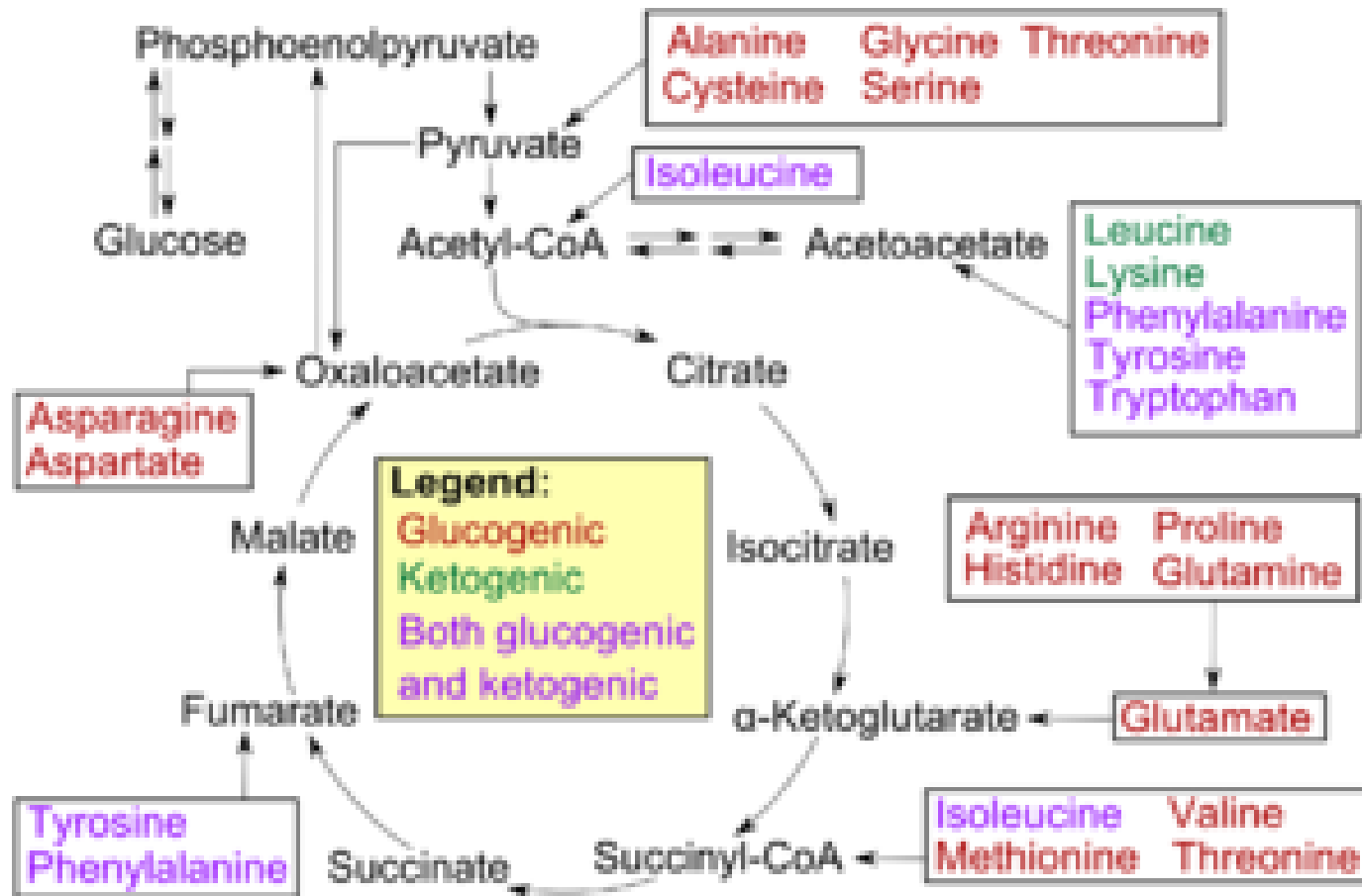
# Table 1: Digestive Chemicals & Sources

Cell/Hormone

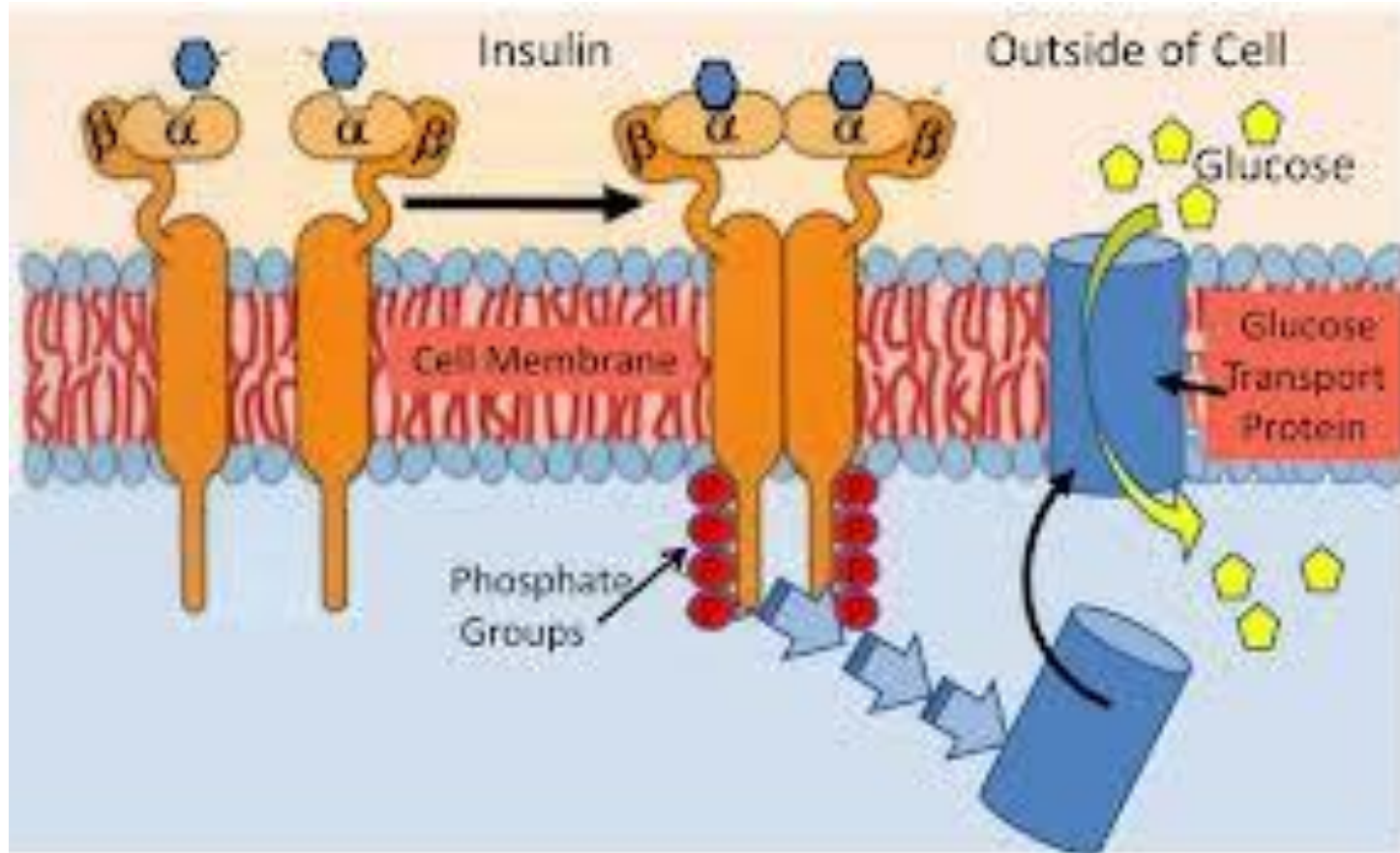
Action

- |                                       |                                |
|---------------------------------------|--------------------------------|
| • $\alpha$ : Glucagon                 | • $\uparrow$ [blood glucose]   |
| • $\beta$ : Insulin & Amylin          | • $\downarrow$ [blood glucose] |
| • PP: Pancreatic Polypeptide          | • $\downarrow$ [blood glucose] |
| • $\epsilon$ : Ghrelin                | • $\uparrow$ [blood glucose]   |
| • $\Delta$ : Somatostatin             | • $\downarrow$ [blood glucose] |
| • Mucosa L cells: GLP-1               | • $\downarrow$ [blood glucose] |
| • Mucosa K cells: GIP                 | • $\uparrow$ [blood glucose]   |
| • Brush border: $\alpha$ glucosidases |                                |

# Kreb's/Gluconeogenesis



# Facilitated Diffusion



# Table 2 - Insulin Functions

- ↓ [blood glucose]
  - Facilitated diffusion
  - ↑ glucogen synthesis
  - ↑ esterification fatty acids
  - ↓ lipolysis
  - ↓ proteolysis\*
  - ↑ amino acid uptake
  - ↓ (inhibits) glucagon release
- Not [blood glucose] related
  - ↓ autophagy
  - ↑ K<sup>+</sup> uptake
  - ↓ in arterial muscle tone
  - ↑ secretion of gastric HCl
  - ↓ blood pressure
  - ↓ renal Na<sup>+</sup> excretion
  - ↑ K<sup>+</sup> excretion/↓ blood [K<sup>+</sup>]

# RISK FACTORS

## Type 1

- Family History
- Possible genetic precursors

## Type 2

- Obesity\*
- Adipose tissue distribution
- Inactivity
- Family history of Type 2 DM
- Ethnicity
- Age
- Prediabetes
- Gestational diabetes
- Large baby (> 9 lbs)

# ETIOLOGY/CONDI TIONS

# Etiology/Conditions → DM <sup>(1)</sup>

- Genetic defects in  $\beta$  cell function
- Exocrine Pancreatic Defects
  - Chronic pancreatitis
  - Pancreatectomy
  - Pancreatic neoplasm
  - Cystic Fibrosis
  - Hemochromatosis
  - Fibrocalculous pancreatopathy



# Etiology/Conditions → DM (2)

- Endocrinopathies
  - Cushing Syndrome
  - Hyperthyroidism
  - Growth Hormone excess (acromegaly)
  - Pheochromocytoma

# Etiology/Conditions → DM (5)

- Drugs
  - Atypical antipsychotics
  - $\beta$ -adrenergic agonists
  - Calcium Channel blockers
  - Corticosteroids
  - Niacin
  - Phenothiazines
  - Thiazide diuretics
  - Thyroid hormone
  - Phenytoin
  - Statins
  - Estrogen

# DM PATHOLOGY

# TYPE 1 – Insufficient Insulin

- $\beta$  cells destroyed in antigen-antibody reaction
- DM occurs when 80 – 90%  $\beta$  cells destroyed

# TYPE 2 – Resistance/Reduction

(1)

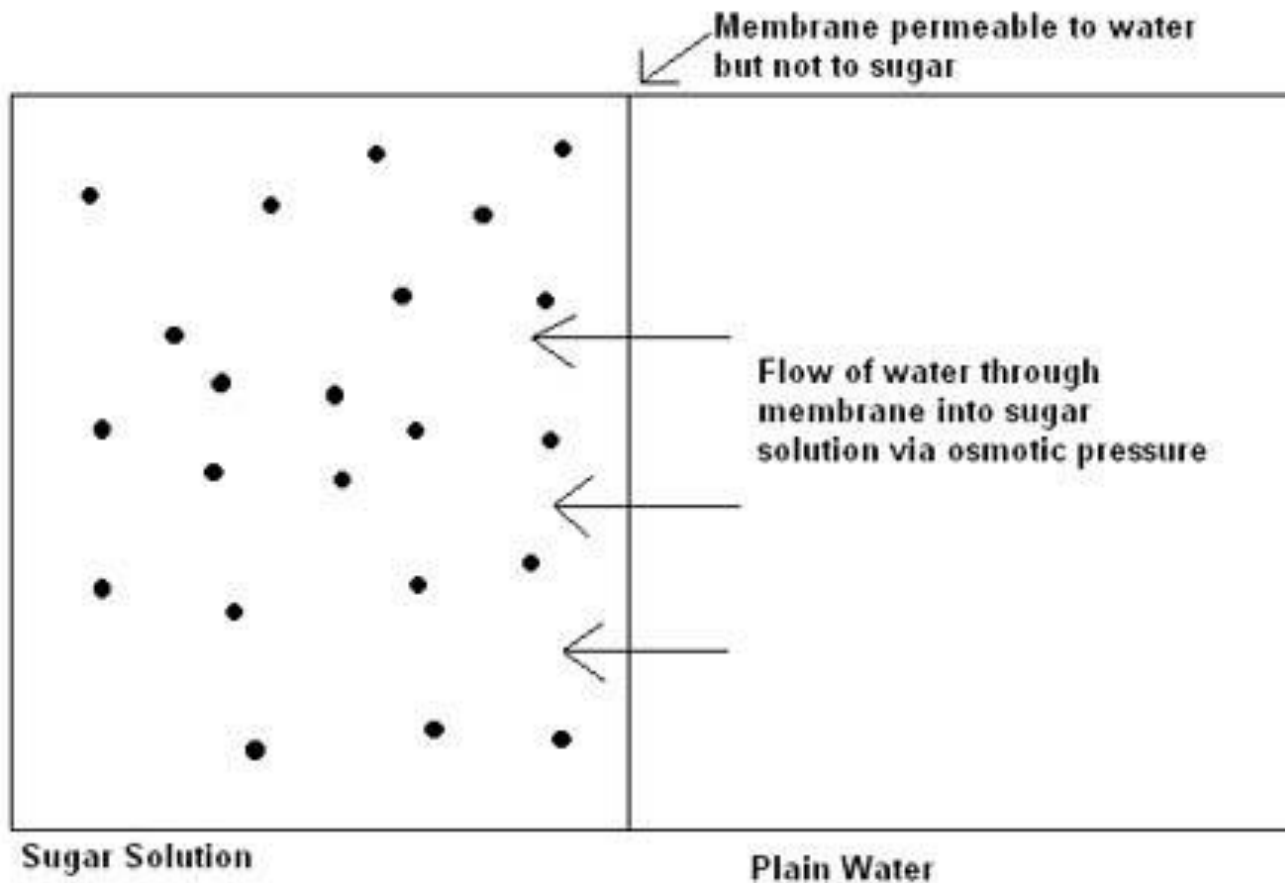
- Insulin resistance
- Contributing Factors:
  - Defective insulin or receptor & post-receptor defects → inability to initiate facilitated diffusion.
  - ↓ intracellular fat & muscle glucose from insulin lack/resistance. Initiates ↑ liver glycogenolysis to ↑ [blood glucose]
  - Insulin resistance → ↑ lipolysis

Types 1 & 2

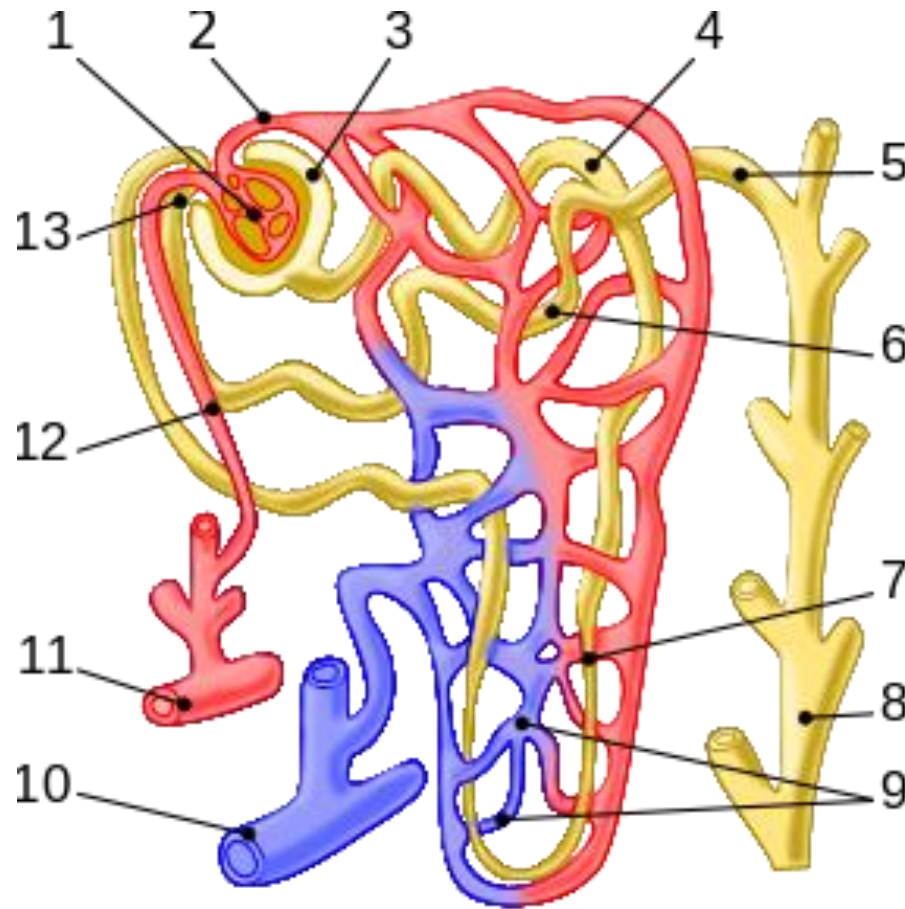
# **DM SYMPTOMS**

# Osmotic Pressure & DM

Fig.1  
Osmotic Pressure



# Kidney Nephron





# DM Symptoms (1)

Symptom	Type		Symptom	Type	
	1	2		1	2
Hyperglycemia	✓	✓	Weight loss	✓	✓
Glycosuria	✓	✓	Fatigue	✓	✓
Polydipsia (thirst)	✓	✓	Blurred vision	✓	✓
Polyuria (frequent urination)	✓	✓	Slow healing/freq infections		✓
Polyphagia (hunger)	✓	✓	Acanthosis nigricans		✓

# DM Symptoms (2)

Symptom	Type	
	1	2
Lethargy	✓	
Stupor	✓	
Ketoacidosis (DKA)	✓	unusual
Abdominal pain	✓	
Nausea/Vomiting	✓	
Hyperosmolar Hyperglycemic Nonketotic State (HHNK)		rare

# Diabetic Ketoacidosis Sx

- Kussmaul breathing
  - $\text{H}_2\text{O} + \text{CO}_2 \rightleftharpoons \text{H}_2\text{CO}_3 \rightleftharpoons \text{H}^+ + \text{HCO}_3^-$
- Fruity (alcohol) smelling breath
- Dry skin & mouth
- Flushed face
- Nausea & vomiting
- Stomach pain

# HHNK Sx

- Severe hyperglycemia
- Extreme dehydration
- Hyperosmolar plasma
- Altered consciousness, confusion or disorientation to coma without significant ketosis (seizures & death)

# Hypoglycemic Symptoms

(1)

- Sweating
- Hunger
- Weakness
- Anxiety
- Dizziness/lightheaded
- Pale skin
- Shakiness
- Rapid or irregular HR
- Fatigue
- Headache
- Blurred vision
- Irritability

# Hypoglycemic Symptoms

(2)

Later Symptoms (mistaken for intoxication)

- Lethargy
- Confusion
- Behavior Change
- Poor coordination
- Convulsions

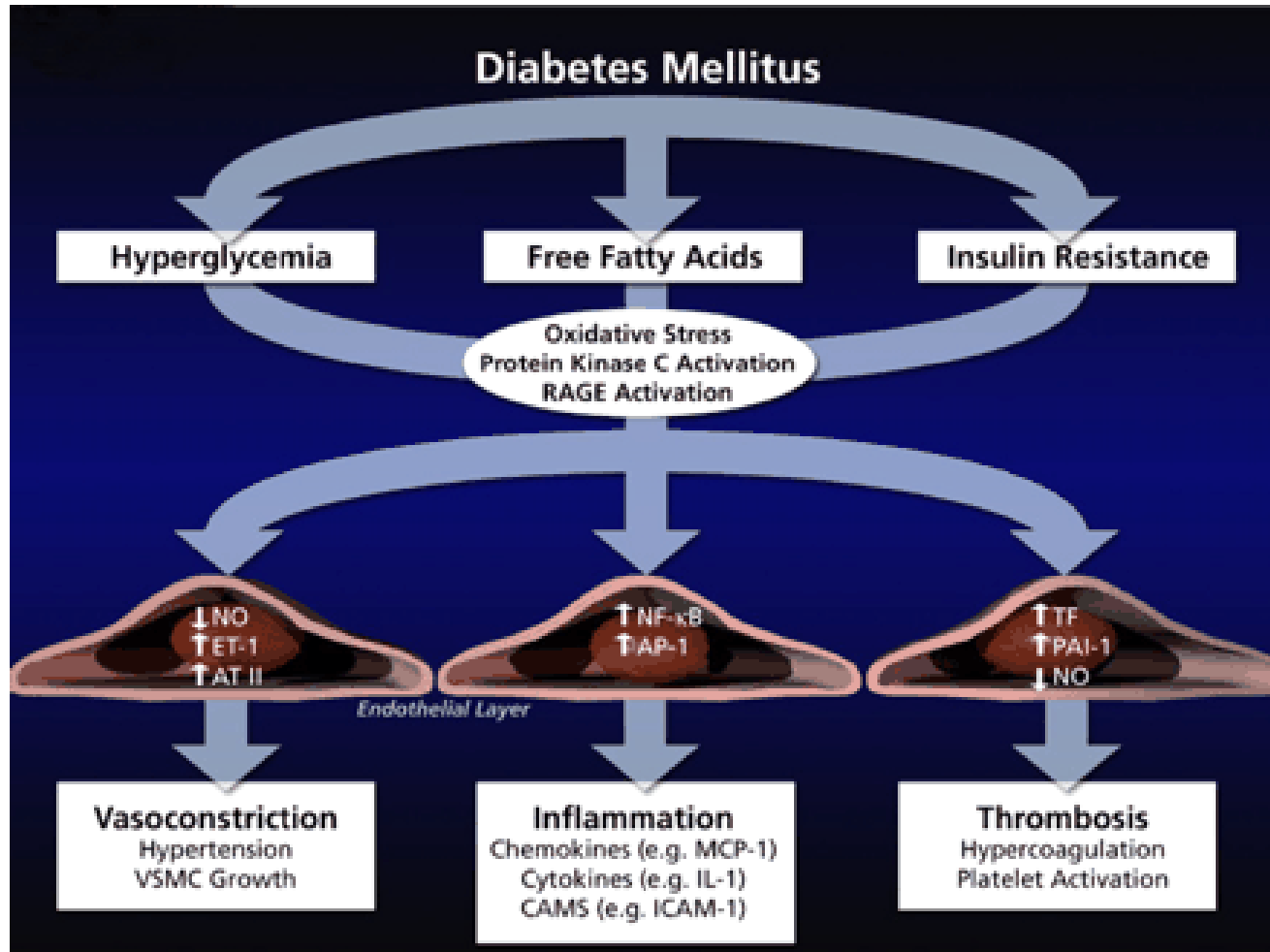
# Hyperglycemic Symptoms

- Frequent urination
- Increased thirst
- Blurred vision
- Fatigue
- Nausea
- Irritability
- Hunger
- Difficulty concentrating

# COMPLICATIO NS



# Diabetic Vascular Disease



# Macroangiopathy

- Stroke & Cerebrovascular Disease
- Coronary artery Disease

(These are large vessel diseases → decreased blood supply (ischemia) from atherosclerosis secondary to vessel endothelial dysfunction plus: procoagulant state and antifibrinolytic state)

# Microangiopathy

- Retinopathy
- Nephropathy

# Retinopathy

Non-proliferative  
diabetic retinopathy



Aneurysm

Hemorrhage

Hard  
exudate

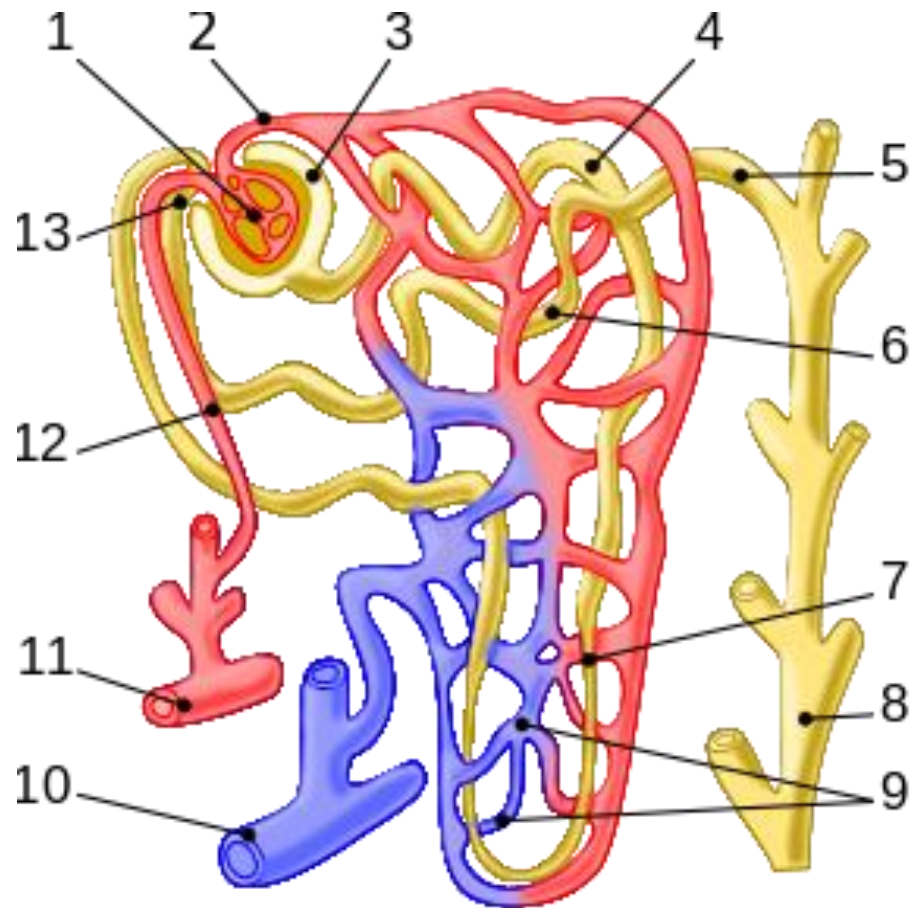
Proliferative  
diabetic retinopathy



Growth of abnormal  
blood vessels

ADAM.


# DM Nephropathy

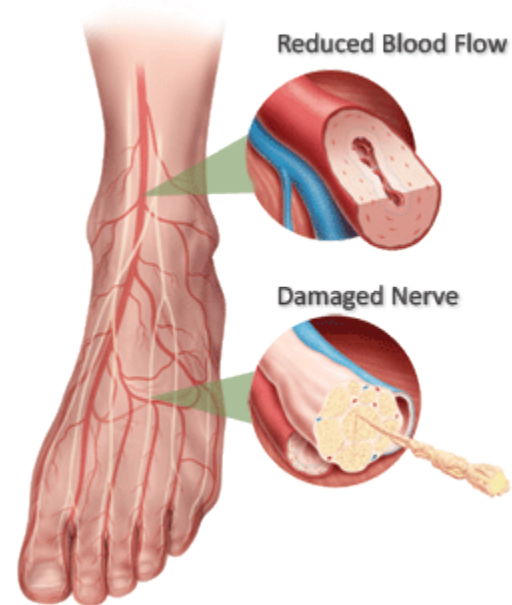


# Autonomic Neuropathy

- Gastroparesis
- Diarrhea
- Impotence/Sexual dysfunction
- Orthostatic Hypotension

















# Peripheral Neuropathy & Microangiopathy

-  Light touch, vibratory & temp sensation
- Lost foot proprioception & possible eventual ataxia, gait problems
- Ulceration
- Necrosis



# Blood

## Pressure/Hypertension

Circulatory System (CS)	Change	B/P change
Heart stroke volume		
		
Heart Rate		
		
Artery volume		
		
Blood Volume:		
		



# TREATMENT

# DM Diagnosis

- History & Physical
- Diagnostic Tests – [blood sugar]
  - Random blood sugars
  - Fasting blood sugar
  - Glycohemoglobin (HbA<sub>1c</sub>)
  - Fructosamine Assay
  - C-Peptide Assay (Connecting Peptide Assay)



## Exercise

Regular exercise helps your body lower blood sugars, promote weight loss, reduce stress and enhance overall fitness.



## Education

All people with diabetes need to learn about their condition in order to make healthy lifestyle choices and manage their diabetes.



## Eat a Healthy diet

What, when and how much you eat plays an important role in regulating how well your body manages blood sugar levels.



## Healthy Weight

Maintaining a healthy weight is especially important in the control of Type 2 Diabetes.



## Lifestyle Management

Learning to reduce stress levels in day-to-day life can help people with diabetes better manage their disease.



## Take Medication if needed

Type 1 Diabetes always requires daily injections of insulin. Type 2 Diabetes is controlled through exercise and meal planning and may require medications and/or insulin to assist the body in making or using insulin more effectively.



# Treatment Approach

- T1DM – Absolute insulin lack
- T2DM – Cellular resistance & relative insulin lack
- Balance insulin production/admin with insulin need
- Treatment modalities:
  - Medications – Insulin and oral antidiabetics (monitored)
  - Diet – monitored & goal directed
  - Exercise – monitored and goal directed

**DM**

**MEDICATIONS**

# Insulins - Rapid & Short Acting

Name	Onset	Peak	Duration
<b>Rapid -Acting</b>			
Humalog/Lispro	15 – 30"	30 – 90"	3 – 5 hours
Novolog/Aspart	10 – 20"	40 – 50"	3 – 5 hours
Apidra/Glulisine	20 - 30"	30 – 90"	1 – 1½ hours
<b>Short -Acting</b>			
Regular/Humulin	30" – 1 hour	2 – 5 hours	5 – 8 hours
Velsulin (pump)	30" – 1 hour	2 – 3 hours	2 – 3 hours

# Insulins – Intermediate & Long-Acting

Name	Onset	Peak	Duration
<b>Intermediate-Acting</b>			
NPH (N)	1 – 2 hrs	4 – 12 hrs	18 – 24 hrs
Lente (L)	1 – 2½ hrs	3 – 10 hrs	18 – 24 hrs
<b>Long-Acting</b>			
Ultralente (U)	30" – 3 hrs	10 – 20 hrs	20 – 36 hrs
Lantus	1 – 1½ hrs	No peak	20 – 24 hrs
Levemir/Detemir	1 – 2 hrs	6 – 8 hrs	Up to 24 hrs

# Insulins – Pre-Mixed

Name	Onset	Peak	Duration
Humulin 70/30	30"	2 – 4 hrs	14 – 24 hrs
Novolin 70/30	30"	2 – 12 hrs	Up to 24 hrs
Novolog 70/30	10 – 20"	1 – 4 hrs	Up to 24 hrs
Humulin 50/50	30"	2 – 5 hrs	18 – 24 hrs
Humalog mix 75/25	15"	30" – 2 ½ hrs	16 – 20 hrs



# Self Administration

- Injection using 31 gauge, 5/16" long needle @ 90° angle for most; 45° for thin people
- Self injection, rotation of abdomen & thighs
- Tissue damage eventually leads to:
  - Hardened skin with lumps & dimpling
  - Weakened underlying fatty tissue (lipodystrophy)
  - ↓ insulin absorption → difficulty in controlling [blood glucose] levels

# Oral Antidiabetic Agents - List

- $\alpha$ -glucosidase inhibitors – Acarbose, Miglitol
- Biguanide – Metformin HCl
- Glucagon-Like Peptide (GLP-1) agonists – Exenatide, Liraglutide
- Dipeptidyl peptidase-4 inhibitors - Linagliptin, Sitagliptin, Saxagliptin
- Human Amylin Analogue – Pramlintide
- Meglitnide/Meglitnide derivative – Repaglinide, Nateglinide
- Sulfonylurea – Glimepiride, Glipizide, Glyburide

# Oral Antidiabetic Agents - List

- Combination Medications
  - Metformin HCl & Linagliptin
  - Metformin HCl & Sitagliptin
- Weight Loss Drugs
  - Lorcaserin/Belviq®
  - Phentermine/Topiramate

# Diabetes and Obesity

- Does obesity cause DM-Type 2?
- Developed eating habits early in life
- Body Mass Index
- Losing weight is simple, not easy
- Life-style change

# Diabetes and Obesity (2)

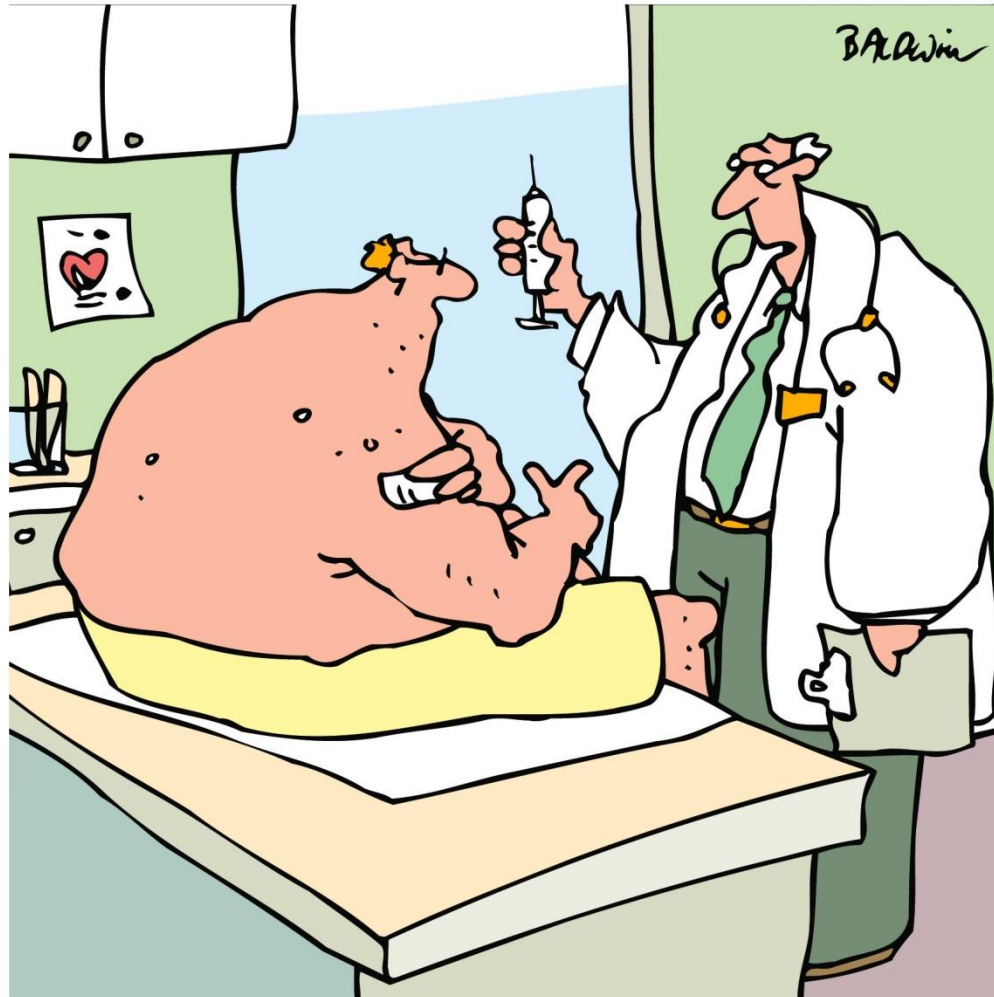
- BODY FAT % RANGES FOR MEN

RATING	AGE				
	20-29	30-39	40-49	50-59	60+
LOW	<13	<14	<16	<17	<18
NORMAL	14-20	15-21	17-23	18-24	19-25
MODERATE	21-23	22-24	24-26	25-27	26-28
HIGH	>23	>24	>26	>27	>28

# Diabetes and Obesity (3)

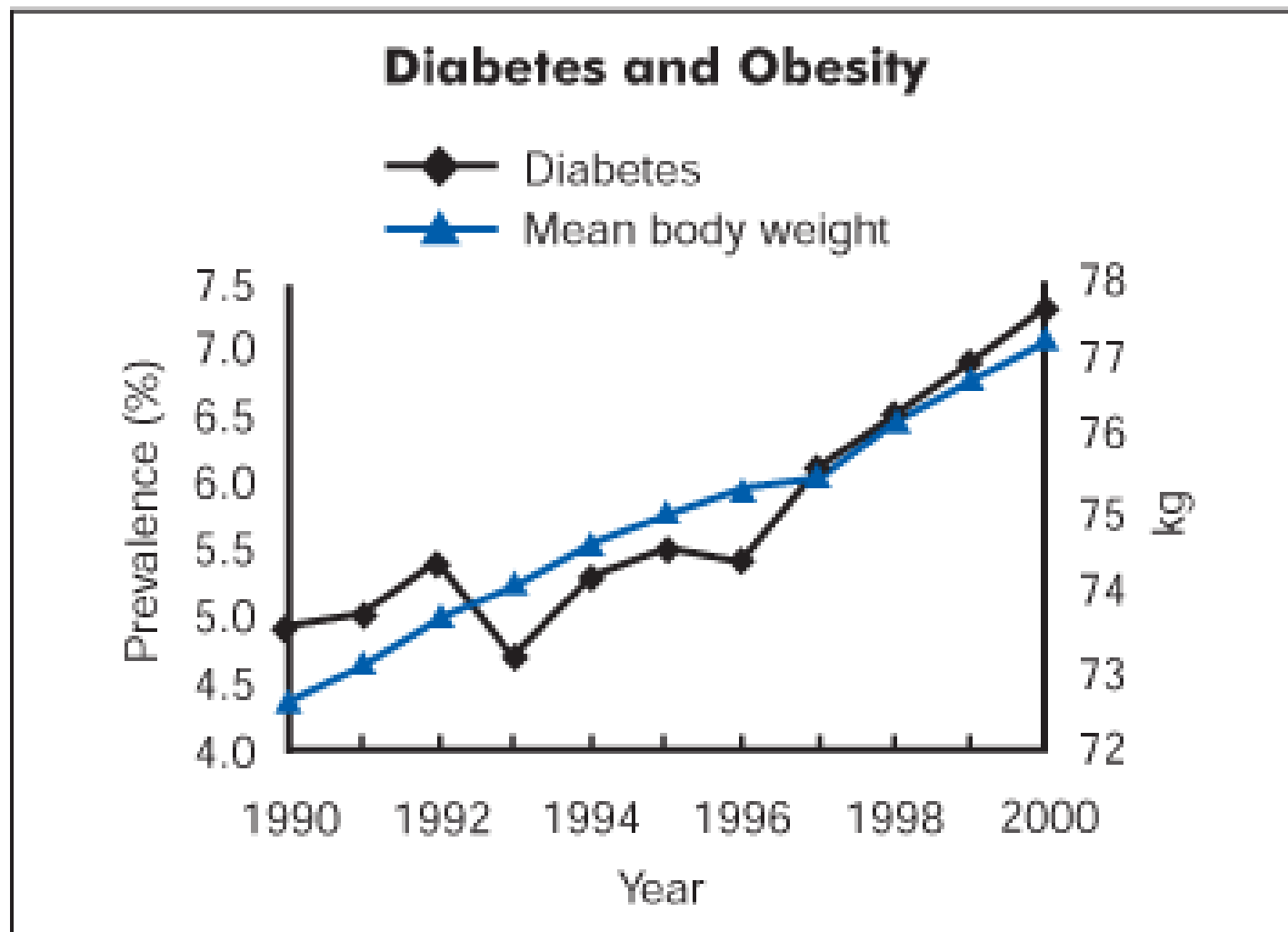
- BODY FAT % RANGES FOR WOMEN

RATING	AGE				
	20-29	30-39	40-49	50-59	60+
LOW	<19	<20	<21	<22	<23
NORMAL	20-28	21-29	22-30	23-31	24-32
MODERATE	29-31	30-32	31-33	32-33	33-35
HIGH	>31	>32	>33	>34	>35



“It wasn’t really insulin. You don’t have diabetes yet. It was just a warning shot.”

**Figure 2. Diabetes and Obesity**





Diet

**DIABETES &**

# Diet - Sources (1)

- Nutritionist/Dietitian
- Sources:
  - American Diabetics Association:  
[www.diabetics.org](http://www.diabetics.org)
  - Academy of Nutrition and Dietetics (was American Dietetic Association)  
[www.eatright.org](http://www.eatright.org)

# Diet – Intake Amount (2)

- Recommended caloric intake:
  - ♂, active ♀ – 15 calories/lb body weight
  - Most ♀, sedentary ♂, & adults ↑ 55 - 13 cal/lb
  - Sedentary ♀, obese adults – 10 cal/lb
  - Pregnant, lactating ♀ - 15 – 17 cal/lb
  - Example: 200 lb ♂ needs to eat 2000 cal daily to maintain his weight

# Diet - Tracking <sup>(3)</sup>

- Counting calories
- Exchange lists
- Glycemic Index

# Diet – Exchange List

(4)

GROUP	CHO	PROTEINS	FAT	CALORIES
Starch/Bread	15/0.529	3/0.106	TRACE	80
<u>Meat</u>				
Very Lean		7/0.247	0-1/0.035	35
Lean		7/0.247	3/0.106	55
Med-Fat		7/0.247	5/0.176	75
High-Fat		7/0.247	8/0.282	100

# Diet – Exchange List

(5)

GROUP	CHO	PROTEINS	FAT	CALORIES
Vegetable	5/0.176	2		25
Fruit	15/0.529			60
<u>Milk</u>				
Skim	12/0.423	8/0.282	0-3/0.106	90
Low-Fat	12/0.423	8/0.282	5/0.176	120
Whole	12/0.423	8/0.282	8/0.282	150
Fat			5/0.176	45

# Diet – Exchange List

(6)

- Food exchange lists extensive
- To be determined (dietitian)
  - Caloric intake
  - amount of CHO, P & F
  - Minimize Na, fats, cholesterol,
  - Appropriate fiber amount

# Diet – Glycemic Index <sup>(7)</sup>

- Glycemic Index – Measure of how quickly blood glucose level rises compared to glucose standard of 100 after eating a particular food. 95 is high GI value; 20 is low



# Diet – Glycemic Index <sup>(8)</sup>

- Index tied to serving size in grams
- GI charts list foods much like exchange lists
- Problems: amt CHO actually consumed; insulin production; variability of foods; person response; impact speed/persistence

# Diet - Timing <sup>(9)</sup>

- Meal timing
  - For diabetics – important
  - Especially important for those using long acting insulin
  - Intensive insulin therapy more flexible

Exercise

**DIABETES &**

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[www.glasbergen.com](http://www.glasbergen.com)



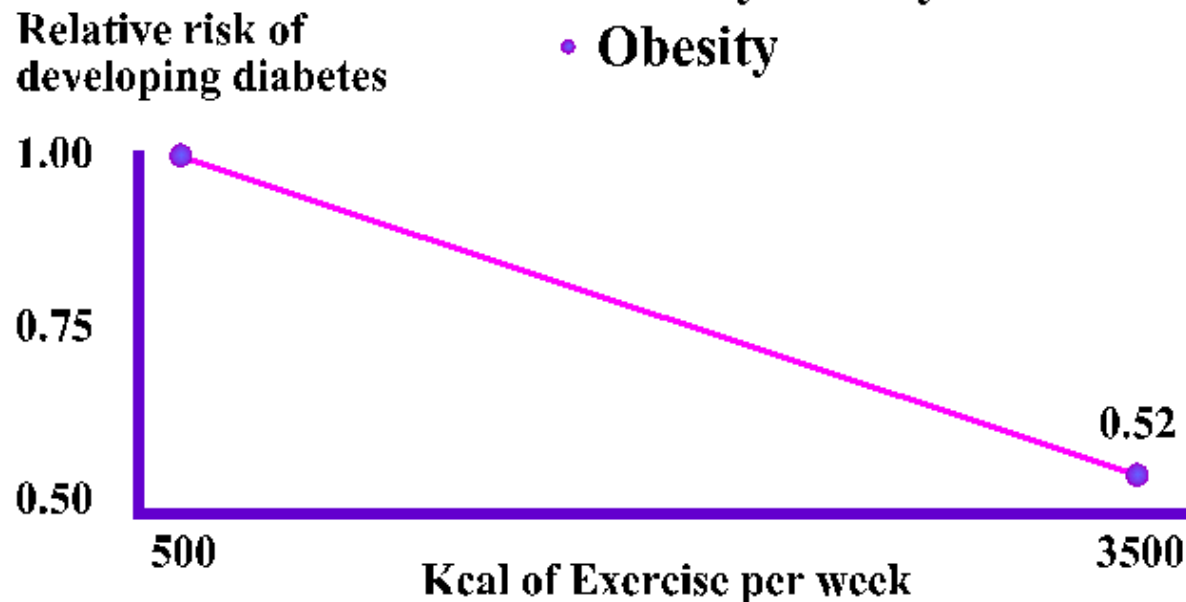
**“What fits your busy schedule better, exercising one hour a day or being dead 24 hours a day?”**

# EXERCISE AND RISK OF DIABETES

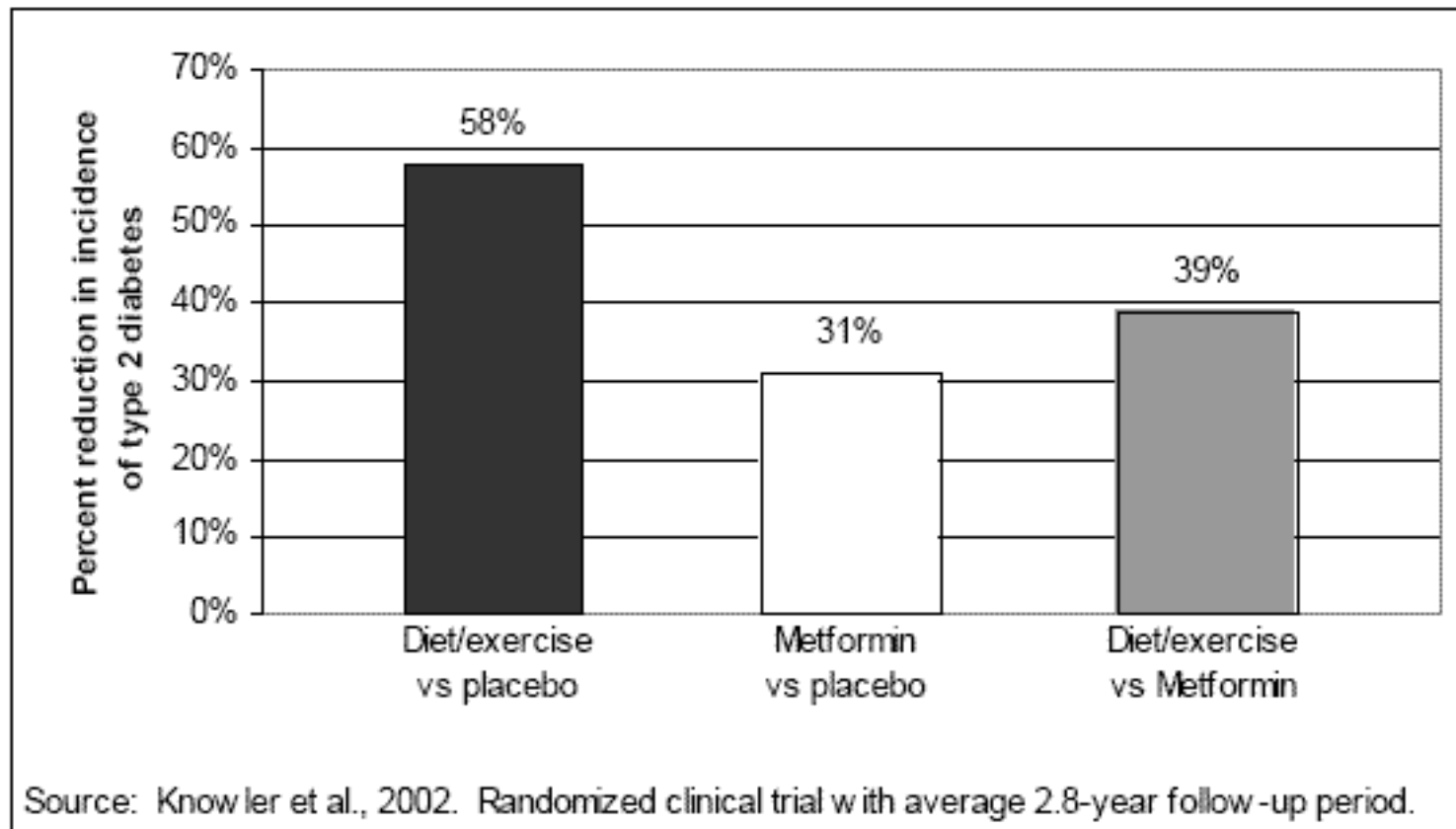
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*Decrease risk of developing diabetes by 50% in those with high risk defined by:*

- High blood pressure
- Family history
- Obesity



# Exercise & Type 2 Diabetes



# Exercise Benefits <sup>(1)</sup>

- Improves body insulin use
- Aerobic exercise can ↓ risk of T2DM
- Aerobic exercise can ↓ complication risk
- May delay/prevent T2DM
- Empties liver glycogen reserves
- ↓ [blood sugar] & fatty acid levels
- ↓  $\beta$  cell workload/excessive production

# Exercise Benefits <sup>(2)</sup>

- Weight loss and control
- Combats health conditions & diseases
- ↑energy, muscle strength, endurance partly do to ↑ body efficiency
- Improves mood
- Promotes better sleep



# Exercise elements (2)

- Mode: walking, swimming, jogging, etc
- Frequency: How often exercise occurs
- Duration: How long exercise lasts
- Intensity: How “hard” exercise is
- Intensity can replace duration somewhat but be careful

# Easy Exercise

- Walk while talking on phone
- Don't use TV remote
- Wash car
- Park car at far end of shopping center lot
- Yard work
- Use stairs

# Exercise Planning <sup>(1)</sup>

- SEE PHYSICIAN FIRST!
- Determine best exercise mode
- Schedule food intake, exercise & medication
- Be care of intense exercise
- With regular exercise, medications may have to be reduced. Check with physician
- Learn what exercise does to [blood sugar]

# Exercise Planning <sup>(2)</sup>

- Have CHO-based food available after exercise
- May need to add CHO to meals
- With MD, adjust insulin as necessary
- Track exercise (intensity, duration, frequency)

# Exercise Cautions <sup>(1)</sup>

- Wear medical alert ID (RoadID.com)
- Exercising when medication is @ peak effect
- Exercising when [blood glucose] is very high
- Watch for Symptoms of hypoglycemia  
(restoring of body balance can take 24 hours)
- Check [blood sugar] before, during, & after  
(learn how exercise effects body)

# Exercise Cautions <sup>(2)</sup>

- Carry small CHO snack such as fruit or fruit drink for possible hypoglycemia during exercise
- Too much exercise (intensity/duration) can cause catecholamine production to ↑ [blood glucose]

# Exercise Cautions <sup>(3)</sup>

- Don't exercise with DM-T1 & positive ketone test & [blood glucose] > 250 mg/dℓ
- If insulin injection necessary, use abdomen rather than arm or leg to absorb insulin more evenly
- Start hydrated and stay hydrated

# Exercise Measures

## Determining Target Range

INTENSITY	% MAX HEART RATE
Very light	< 35
Light	35 – 54
Moderate	55 – 70
Hard	71 – 90
Very Hard	➤ 90
Maximal	100

220 – age. Ex: moderate  $[220 - \text{age}] \times 0.55$  to  $[220 - \text{age}] \times 0.70$



# Bariatric Surgery <sup>(1)</sup>

- Considered appropriate when BMI is:
  - 30 – 35 with significant comorbidities
  - 35 & up with serious coexisting medical conditions such as diabetes
  - 35 – 40 when no comorbidities are present

# Bariatric Surgery <sup>(2)</sup>

- Bariatric Surgery not 1 specific procedure
  - Gastric band (implanted)
  - Partial gastrectomy (“sleeve” gastrectomy or biliopancreatic diversion with duodenal switch)
  - Resection & re-routing of small intestine to small stomach pouch (gastric bypass)
  - Can → long term significant weight loss

# Bariatric Surgery <sup>(3)</sup>

- Bariatric Surgery can result in:
  - Significant long-term weight loss
  - Diabetic resolution/cure
  - Improved cardiovascular risk
  - Reduction of mortality rates from 23 to 40%
- Study showed no survival benefit among older, severely obese people

# DM & Developmental Disabilities (1)

- Incidence of obesity in DD individuals 4x more common than general population
- Problems:
  - Access to healthcare for screening & treatment
  - Inability of those with DD to self manage
  - Inability to understand
  - Flawed view of disease

# DM & Developmental Disabilities (2)

- Source: Prevent, Understand, and Live with Diabetes: A Guide for Individuals with Developmental Disabilities, ARC of New Jersey, 985 Livingston Ave, North Brunswick, NJ 08902
- To request copy call (732) 246-2525, ext. 35 or email [info@arcnj.org](mailto:info@arcnj.org)
- February 2012 document

# DM & Developmental Disabilities (3)

- This guide is for the individual with DM.
- It used relatively simple language and pictures
- It talks about DM prevention, warning signs, blood sugar testing, and living with diabetes.
- It is also available in Spanish