DIABETES

What is diabetes?

- Diabetes mellitus
- Diabainein (Greek)= "to pass through"
- Mellitus (Latin)= "sweetened with honey"
- Glucose spills into urine
- Sweet urine- ants

Diabetes

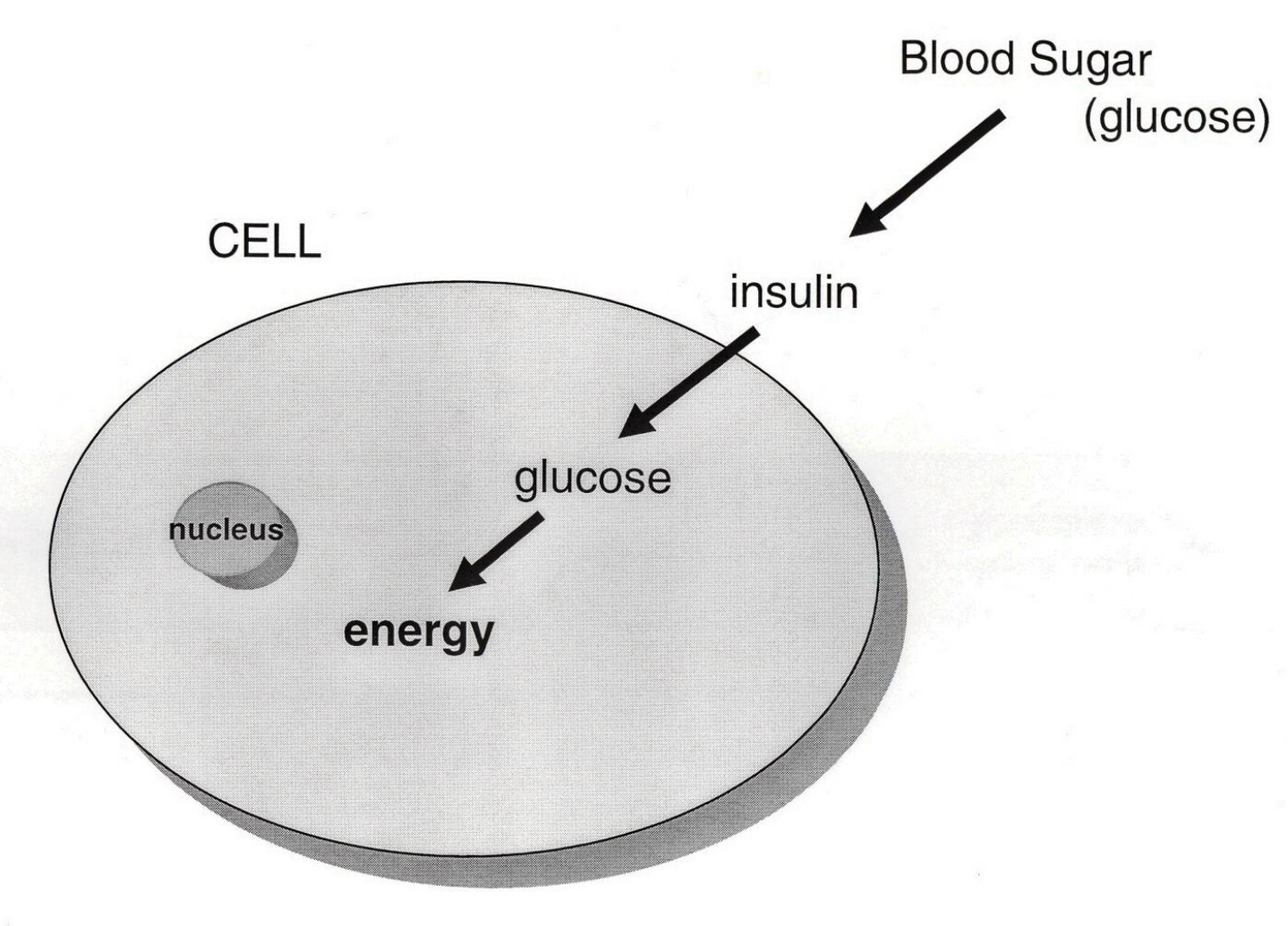
- Consistently ↑ blood glucose
- Result of:

1) ↓ insulin from pancreas

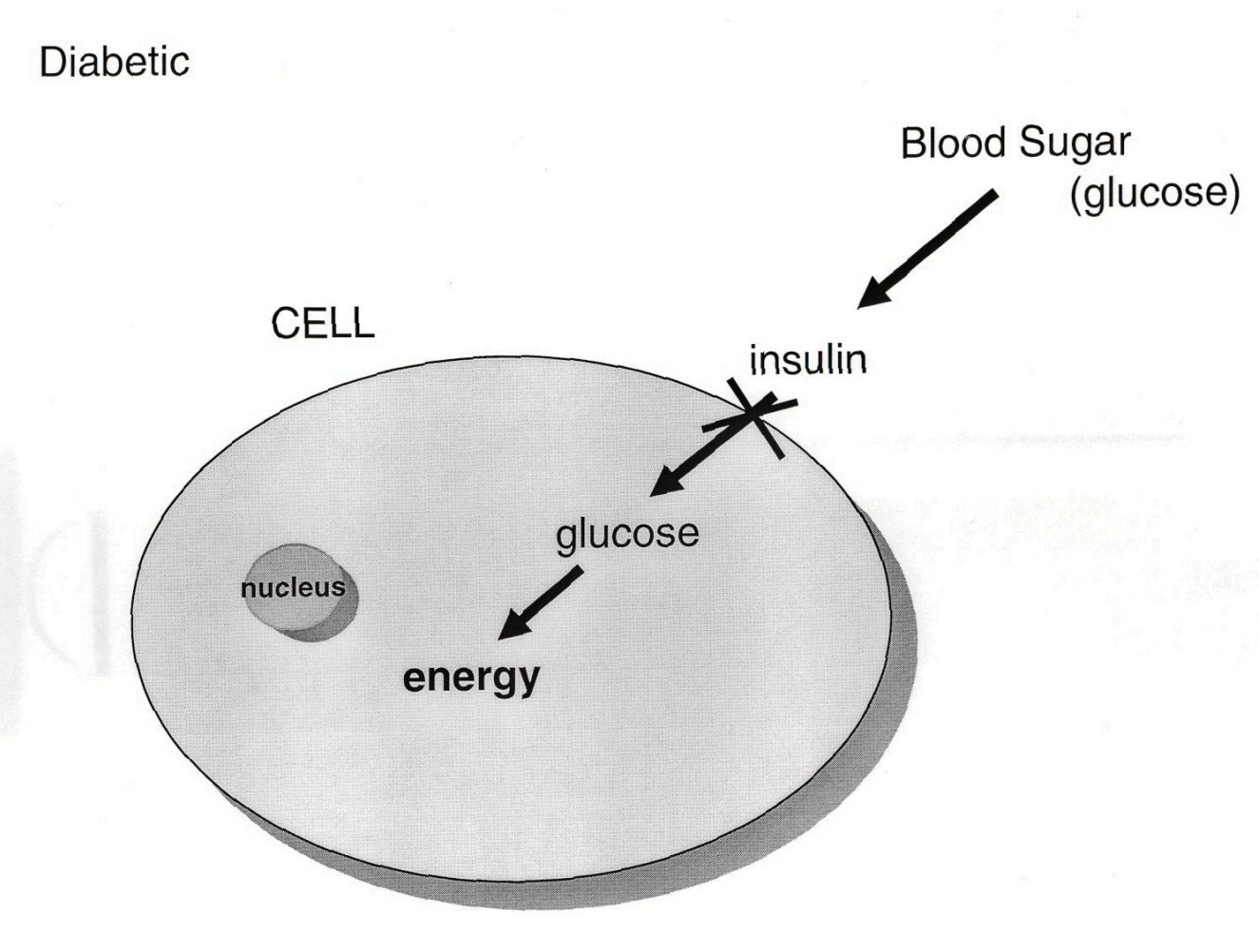
and/or

2) ↓ insulin sensitivity (responsiveness) by body cells

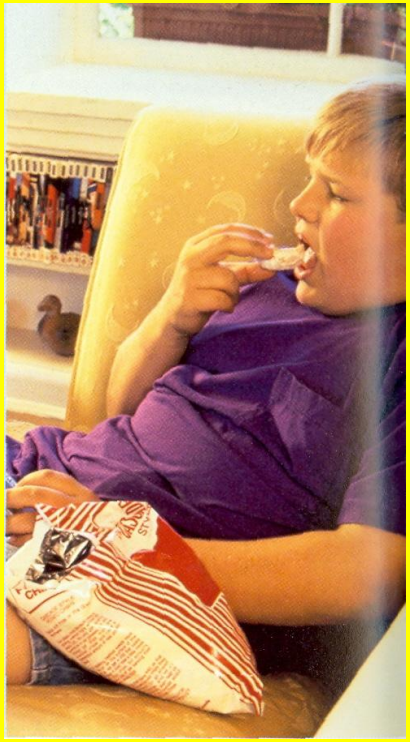
"insulin resistance"

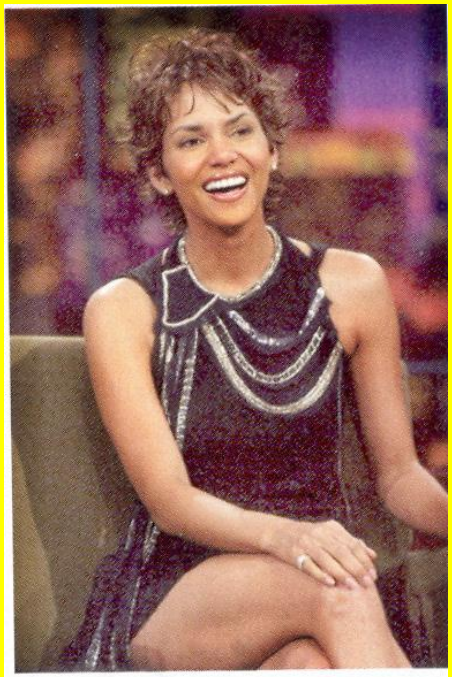

Blood Sugar
(glucose)
CELL
insulin
glucose
nucleus
energy

"Starvation in the midst of plenty"

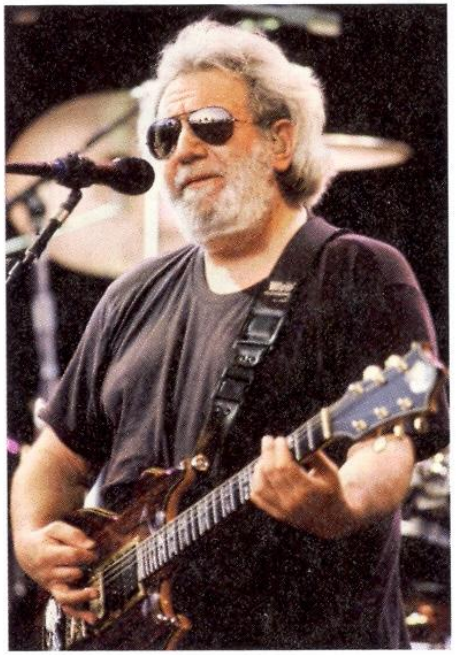


Who gets diabetes? Children, teens, young, old





Actress Halle Berry has type 2 diabetes.

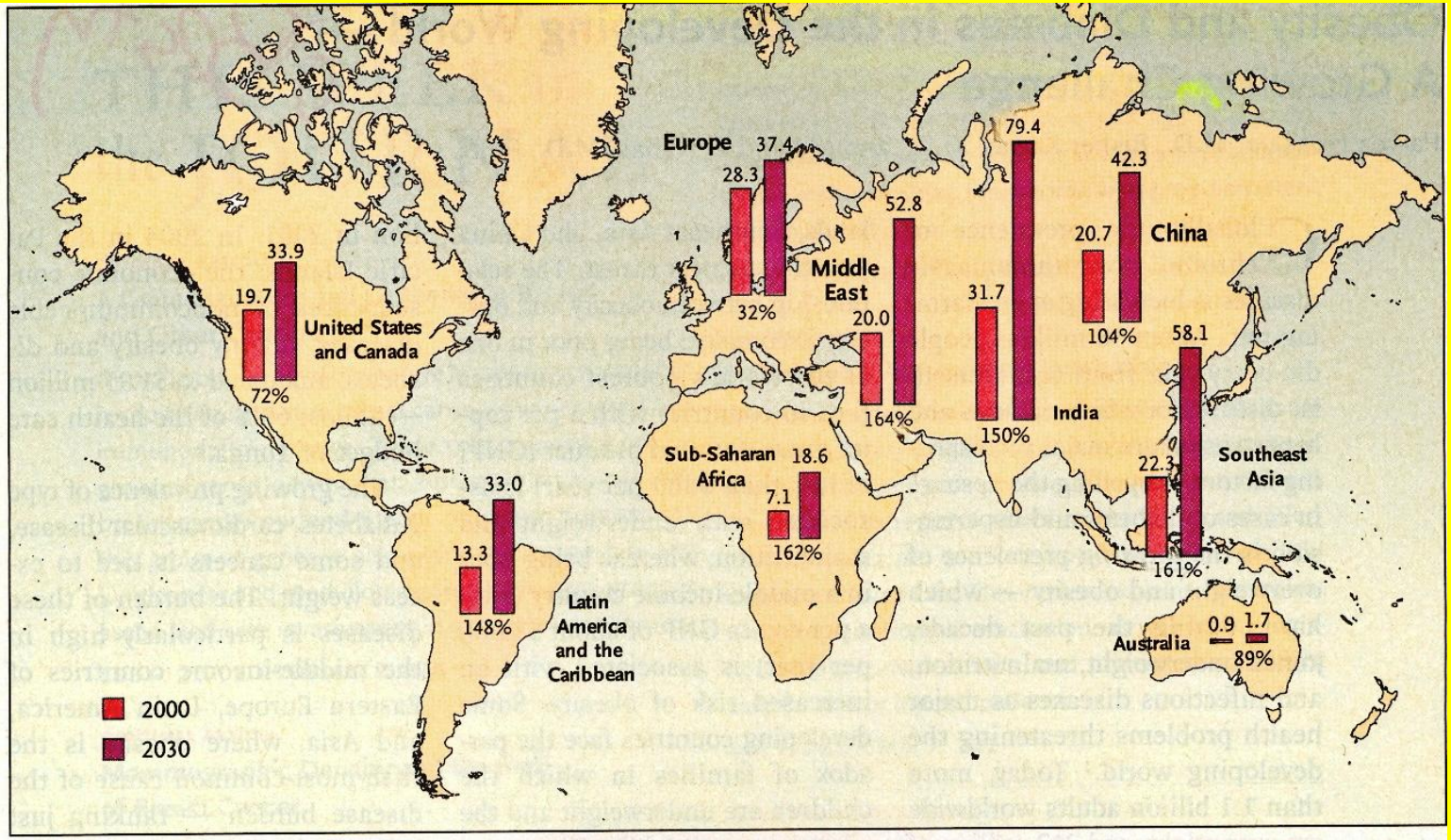


Jerry Garcia, a member of the Grateful Dead, had type 2 diabetes.

Who has diabetes?

- > 16 million Americans have diabetes
- > 20 million Americans: **pre-diabetes**
- Economic cost: **$132** billion medical expenses, disability, lost work

Diabetes Worldwide: 171 million (2000)

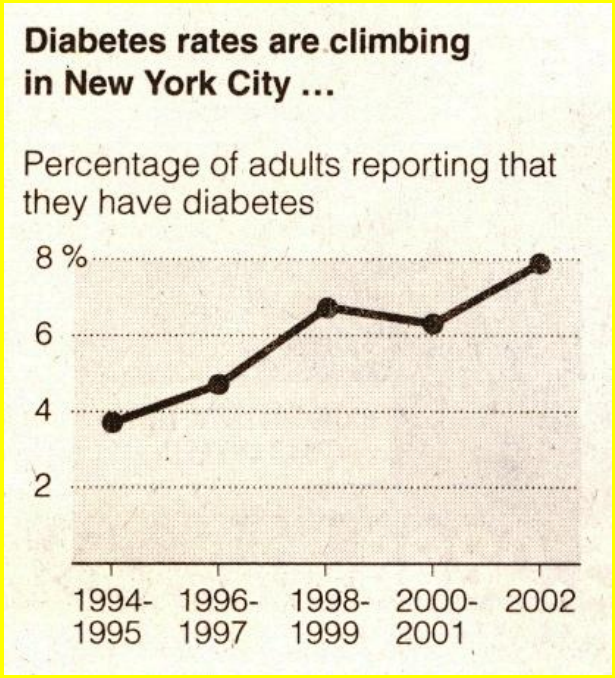


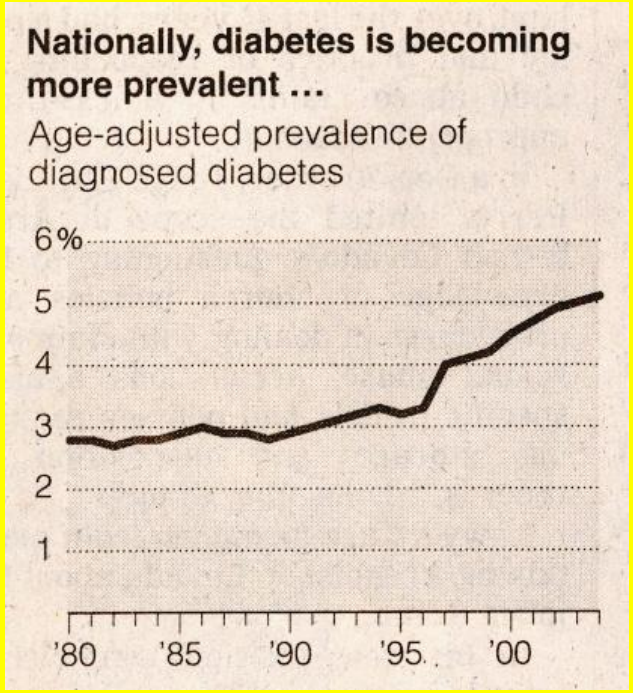
Millions of Cases of Diabetes in 2000 and Projections for 2030, with Projected Percent Changes.

Data are from Wild et al.[3]

Diabetes: 5th leading cause of death in US

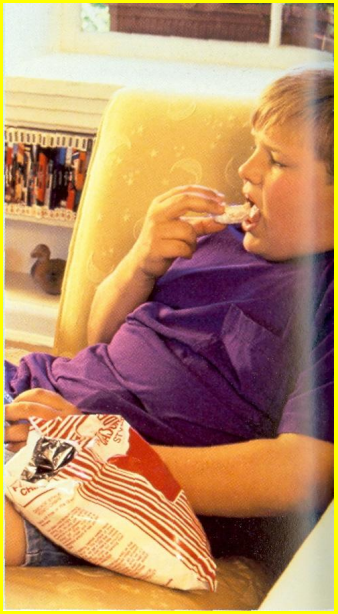
- Diabetes: alarming increase in New York City and the United States





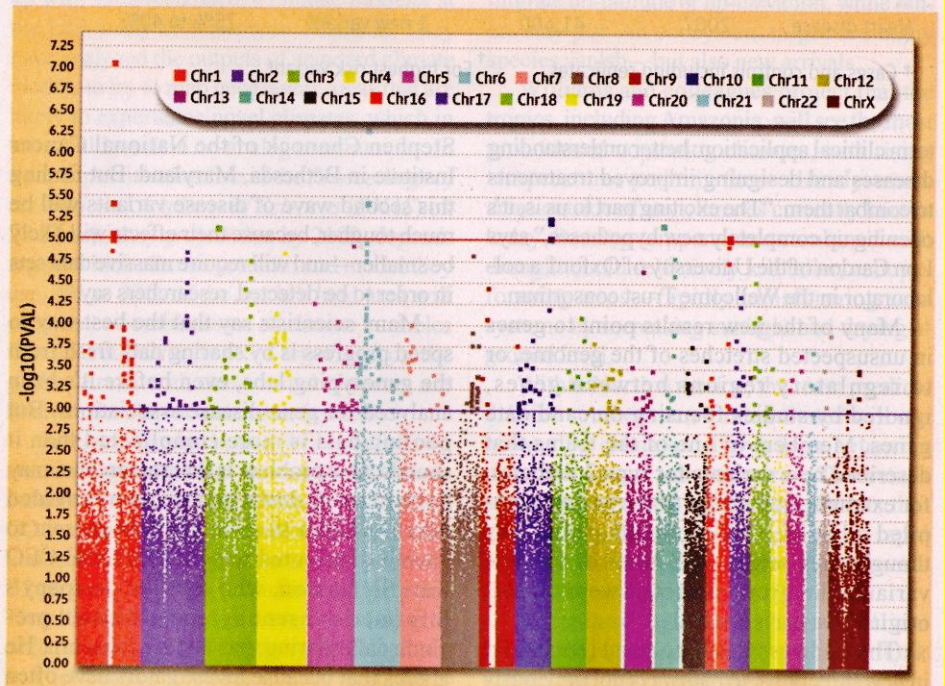
Who's at risk?

- Family history
- Being overweight/obese
- BMI > 25 (fat cells interfere with insulin action)
- Recently: ↑ children (overweight/obese)



10 "Diabetes genes" identified: pre-disposition to diabetes

Chromosome pop-up procedure- **human genome**



Rising to the top. In a genome-wide association study for type 2 diabetes, 386,731 genetic markers, shown here by chromosome, pop up. Those above the higher line appeared to be significantly associated with disease.

Who's at risk?

- Ethnic/racial groups:
  - **A) African-Americans**
  - **B) Native Americans**
  - **C) Hispanic people**
  - **D) Asian Americans**

Who's at risk?

- Woman who had "gestational diabetes" during pregnancy
- Woman- delivered baby > 9 pounds at birth
- Woman with polycystic ovarian syndrome
- ↑ Age: >45 start screening

Who's at risk?

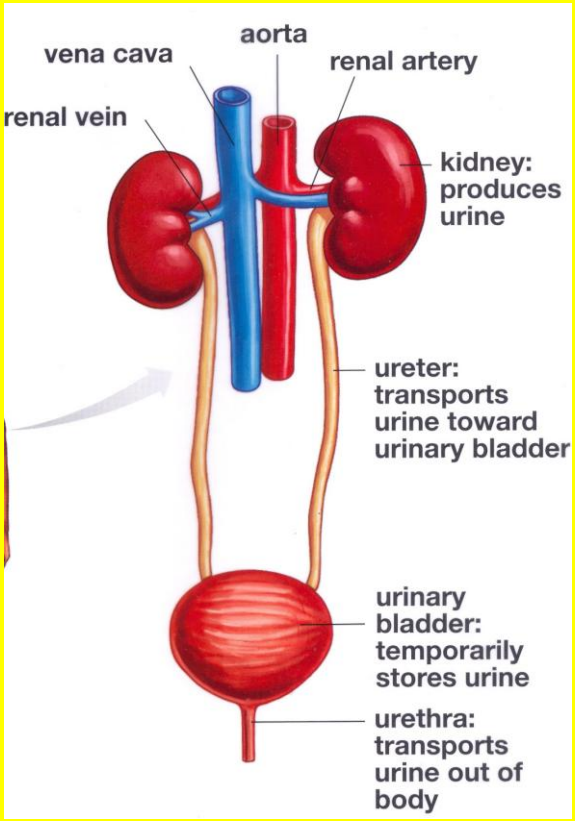
- **Metabolic syndrome**
  - High blood pressure
  - Low HDL, High triglyceride
  - Abdominal obesity
- Borderline ↑ glucose (pre-diabetes)
- ↑ Risk with **inactivity**

Blood Glucose Levels

- Normal glucose narrow range:

  80-120 milligrams/100 ml of blood (homeostasis)
- Uncontrolled diabetic: 200 milligrams or much higher (600)

- Kidney threshold: **180-220** milligrams
- Above this level: glucose spills-urine
- Lost energy



Measuring Blood Glucose

1. After **12** hour **fast**

Range	Blood Glucose
Diabetes	**126** or higher
Pre-diabetes	**100-125**
Normal	**below 100**

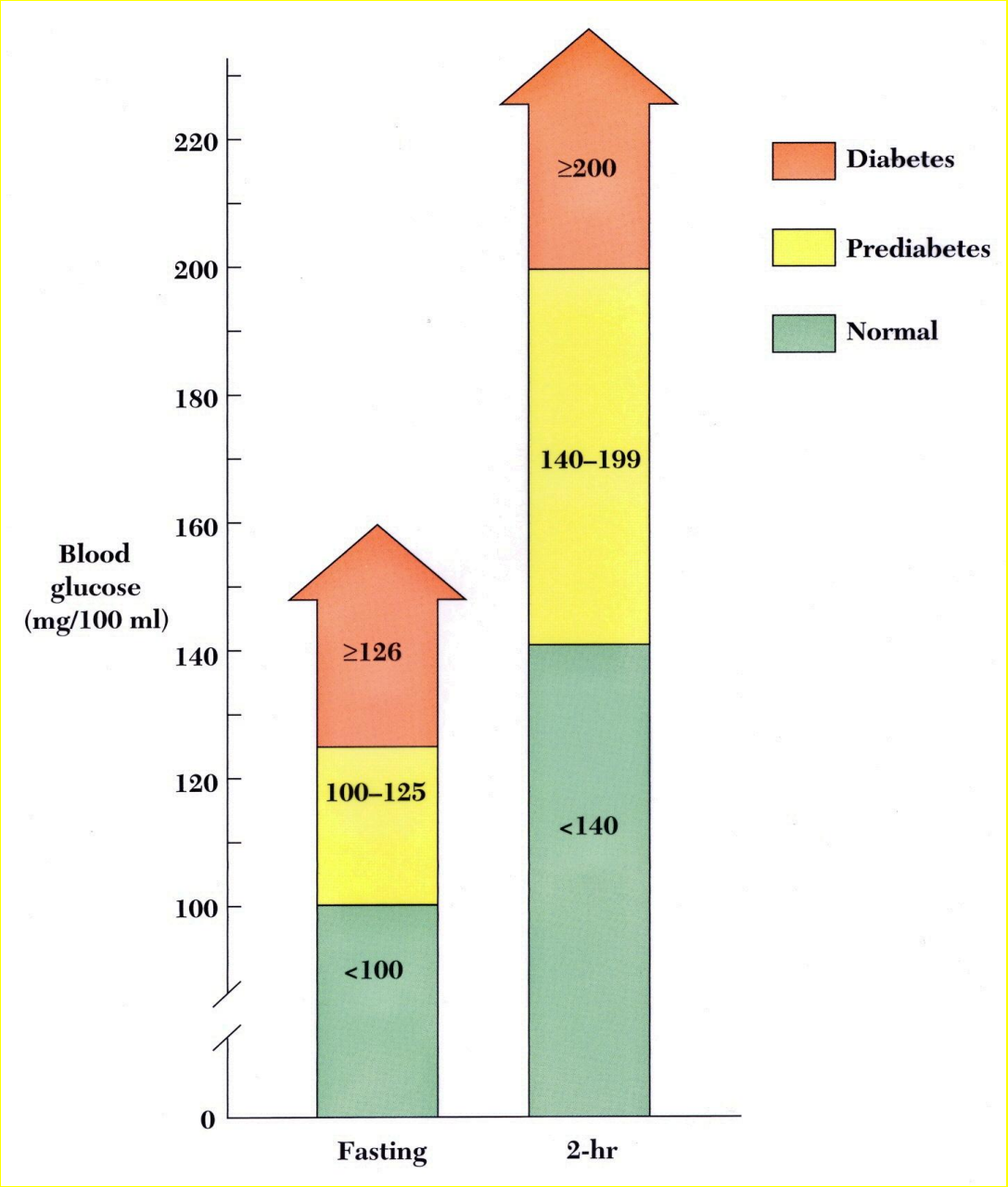
Measuring Blood Glucose

2. **Glucose tolerance test**:
   overnight fast

   Drink 8 ounces- sweet liquid

   Measure glucose every 3 hours

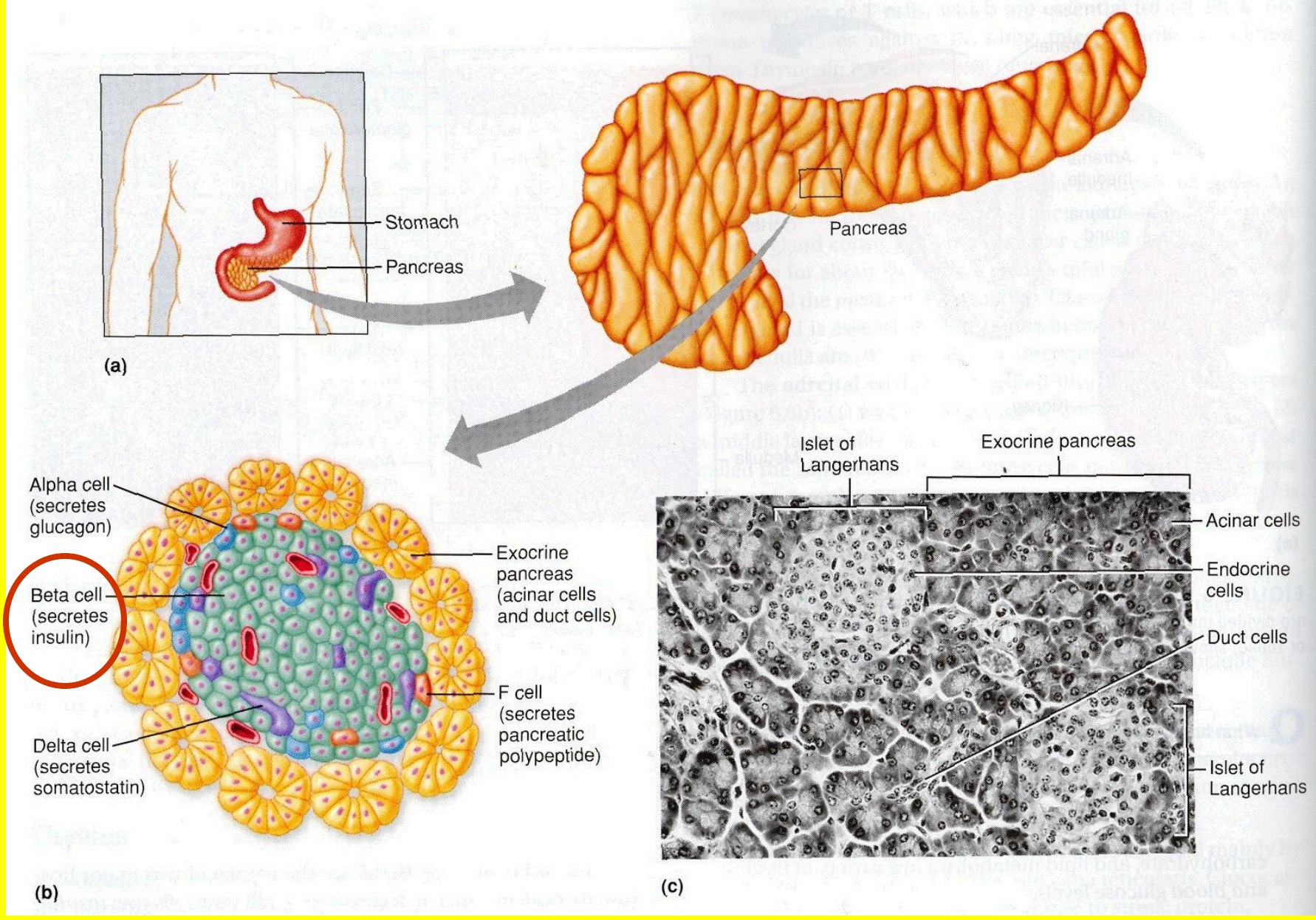
   Look for high blood glucose


Blood glucose (mg/100 ml)
220
200
180
160
140
120
100
0
≥126
100–125
<100
≥200
140–199
<140
Fasting
2-hr
Diabetes
Prediabetes
Normal

Normal Glucose Metabolism

After a meal

1. Carbohydrates digested
2. Glucose absorbed into blood
3. Pancreas senses ↑ blood glucose
4. Releases insulin from **Beta** cells
5. Insulin → blood → body cells


Stomach
Pancreas
(a)
Pancreas
Alpha cell (secretes glucagon)
Beta cell (secretes insulin)
Delta cell (secretes somatostatin)
Exocrine pancreas (acinar cells and duct cells)
F cell (secretes pancreatic polypeptide)
(b)
Islet of Langerhans
Exocrine pancreas
Acinar cells
Endocrine cells
Duct cells
Islet of Langerhans
(c)

6. Insulin ⟺ receptor- cell membrane

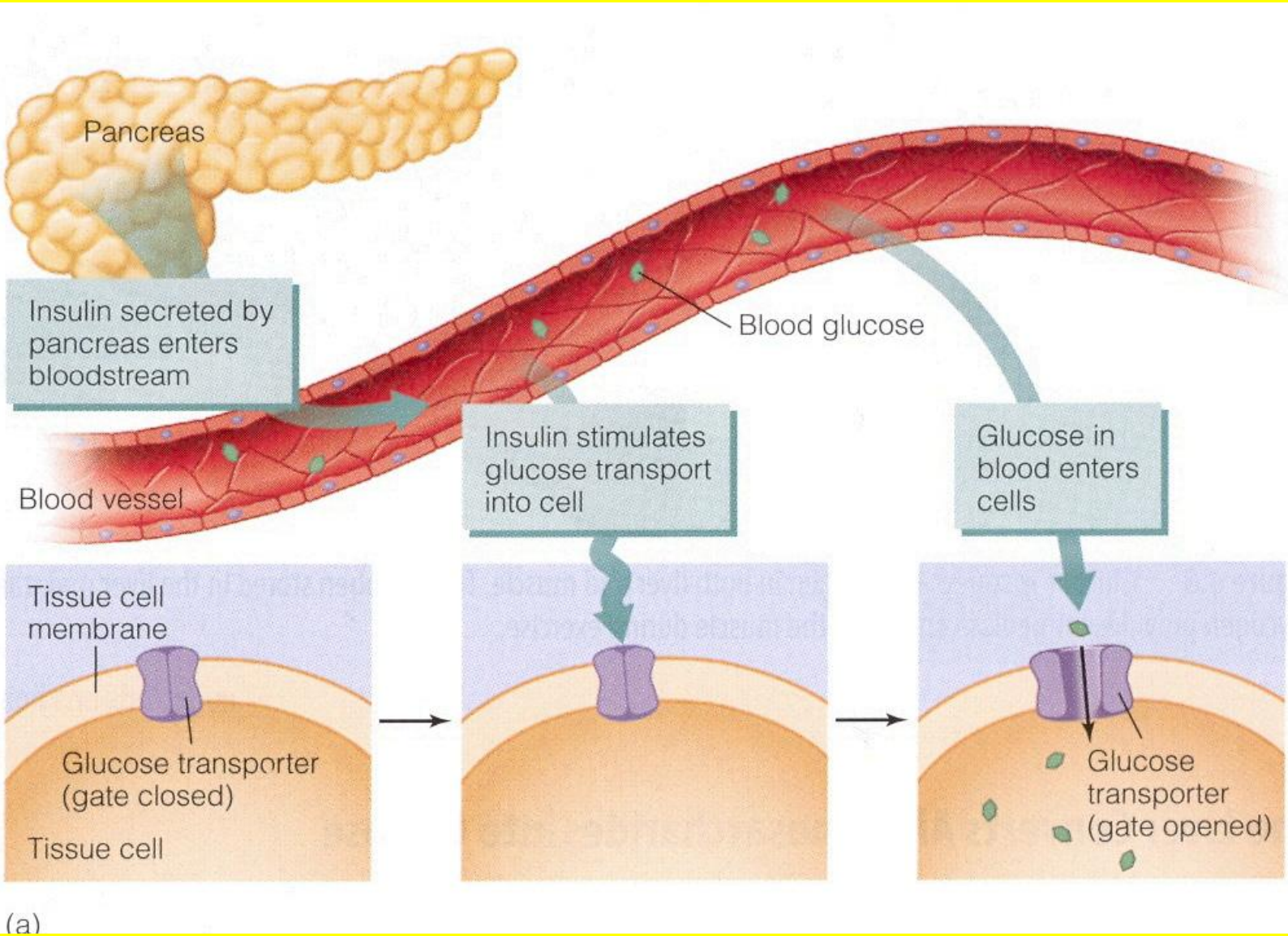
7. "key" opens door:

Glucose outside cell → inside

energy ← cell ↙

or

stored


Pancreas
Insulin secreted by pancreas enters bloodstream
Blood glucose
Blood vessel
Insulin stimulates glucose transport into cell
Glucose in blood enters cells
Tissue cell membrane
Glucose transporter (gate closed)
Tissue cell
Glucose transporter (gate opened)

(a)

8. **Insulin: liver & muscle**

Glucose → **glycogen** (stored)

Bottom line: after meal- excess glucose moved → blood → cells

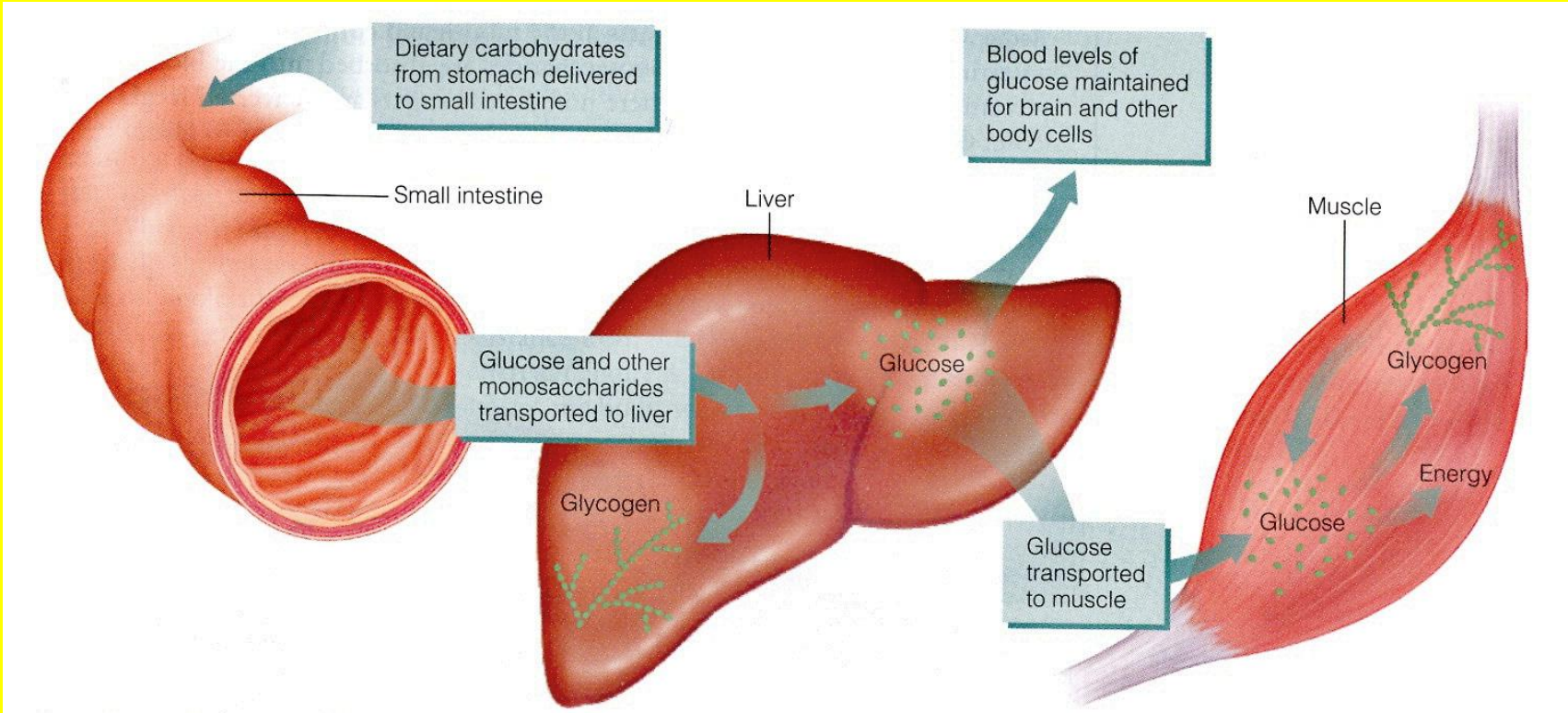
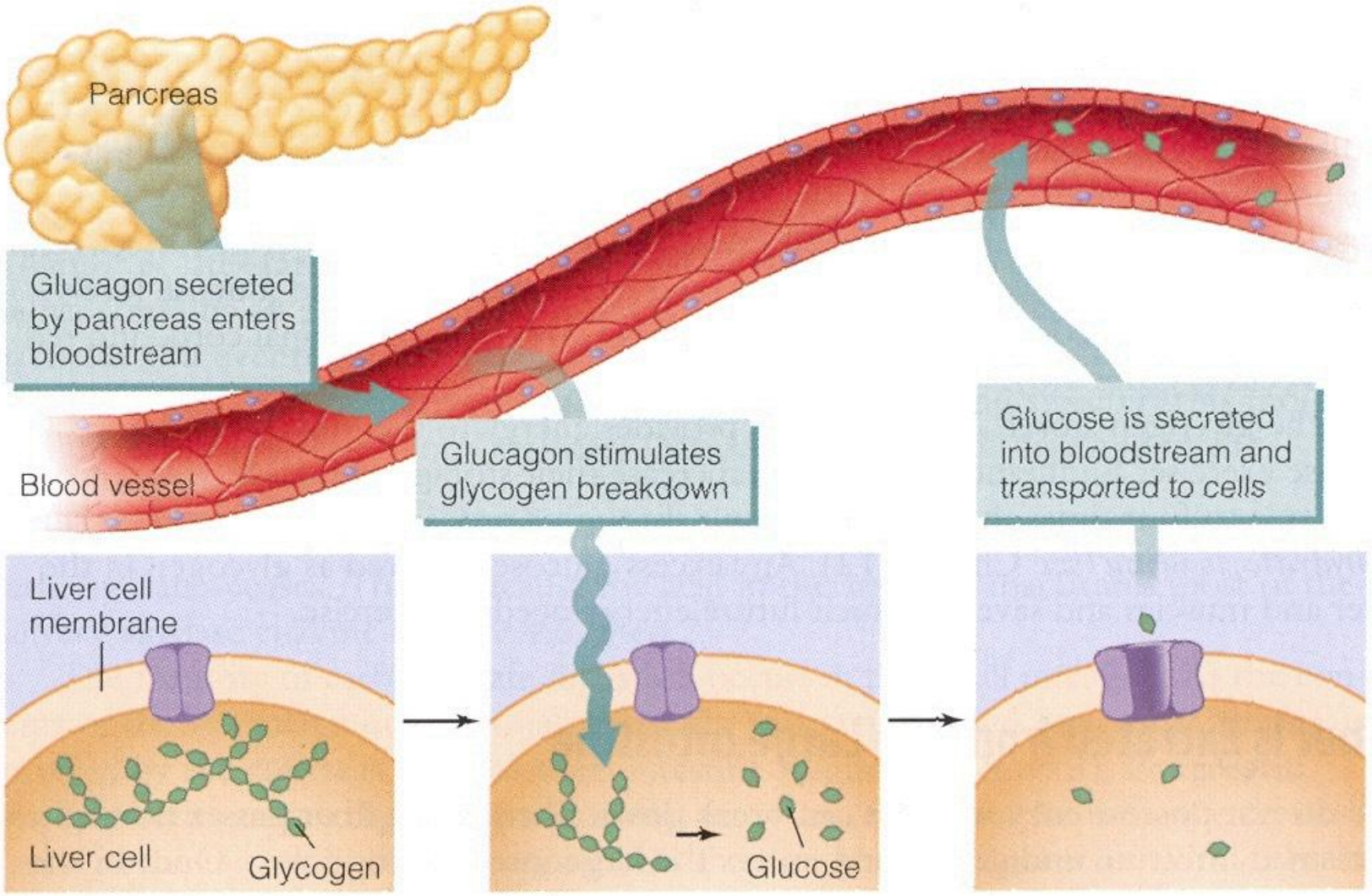


Figure 4.6 Glucose is stored as glycogen in both liver and muscle. The glycogen stored in the liver maintains blood glucose between meals; muscle glycogen provides immediate energy to the muscle during exercise.

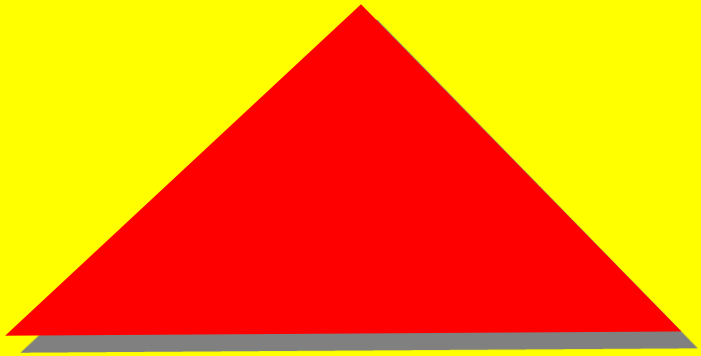
After few hours without food……

1. ↓ blood glucose
2. **Alpha** cells-pancreas → glucagon
3. Does opposite of insulin
4. Glucagon: liver glycogen → glucose → blood
5. Stimulates amino acids → glucose

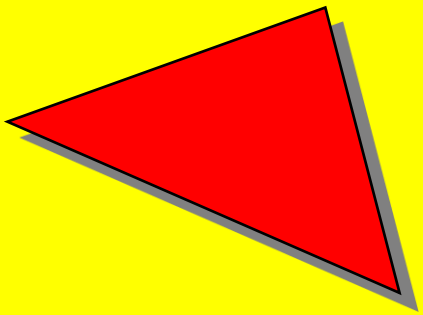

Pancreas
Glucagon secreted by pancreas enters bloodstream
Blood vessel
Glucagon stimulates glycogen breakdown
Glucose is secreted into bloodstream and transported to cells
Liver cell membrane
Liver cell
Glycogen
Glucose

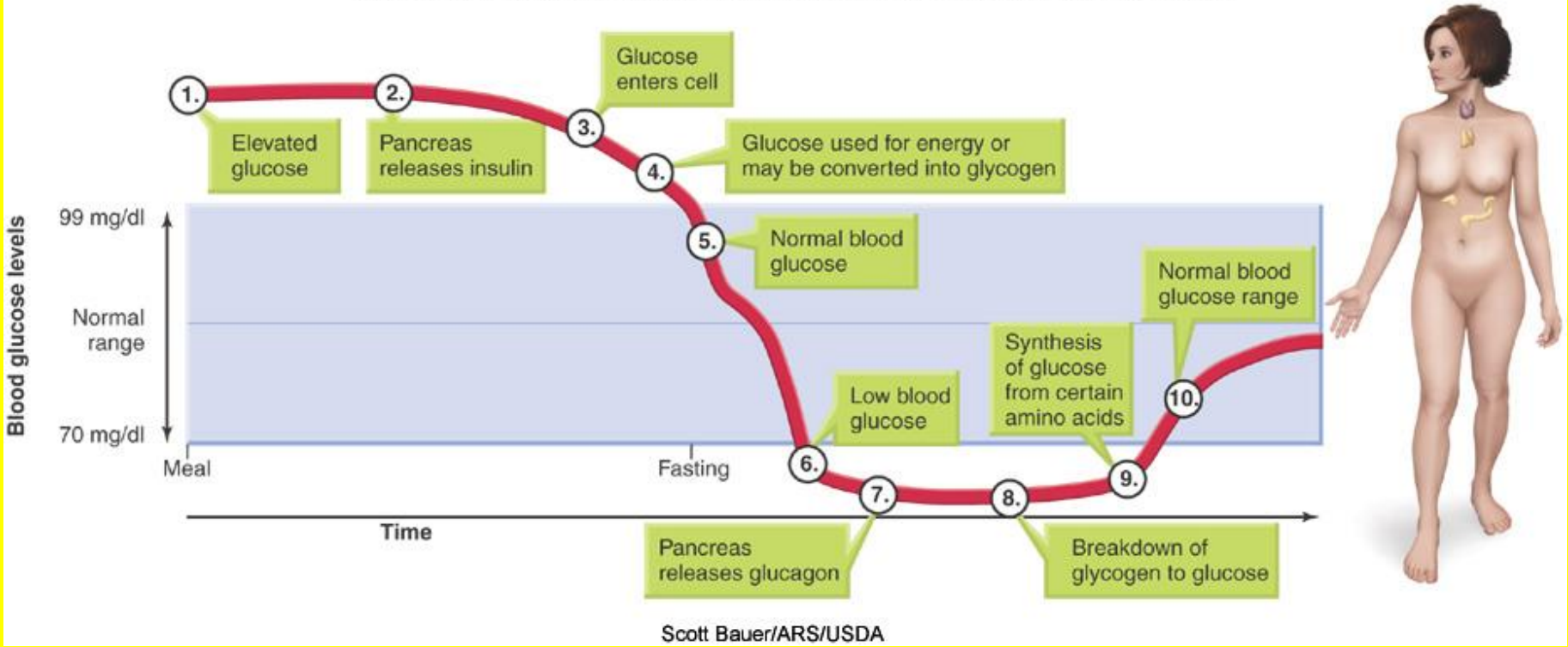
(b)

Insulin & glucagon balance each other

Insulin  Glucagon

Keep blood glucose- normal levels

Diabetes: upsets balance 



Scott Bauer/ARS/USDA

Symptoms (warning signs): diabetes

1. Frequent urination
2. Excessive thirst
3. Extreme hunger
4. Unusual weight loss
5. Increased fatigue
6. Irritability
7. Blurry vision

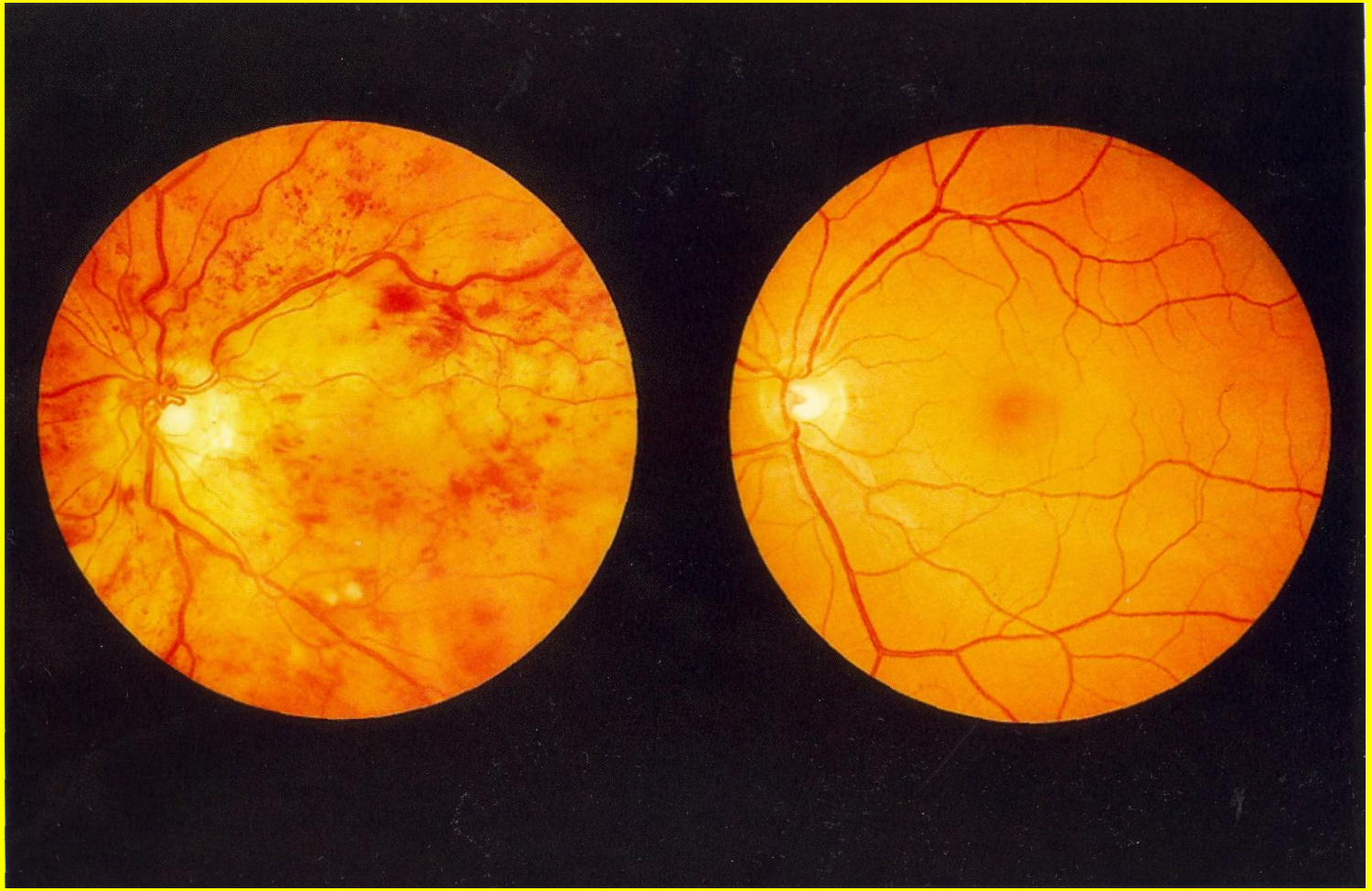
Health Risks

1. ↑ **Risk heart attack/stroke**
2. High glucose sticks to proteins- damages small blood vessels
3. Leading cause: **blindness**

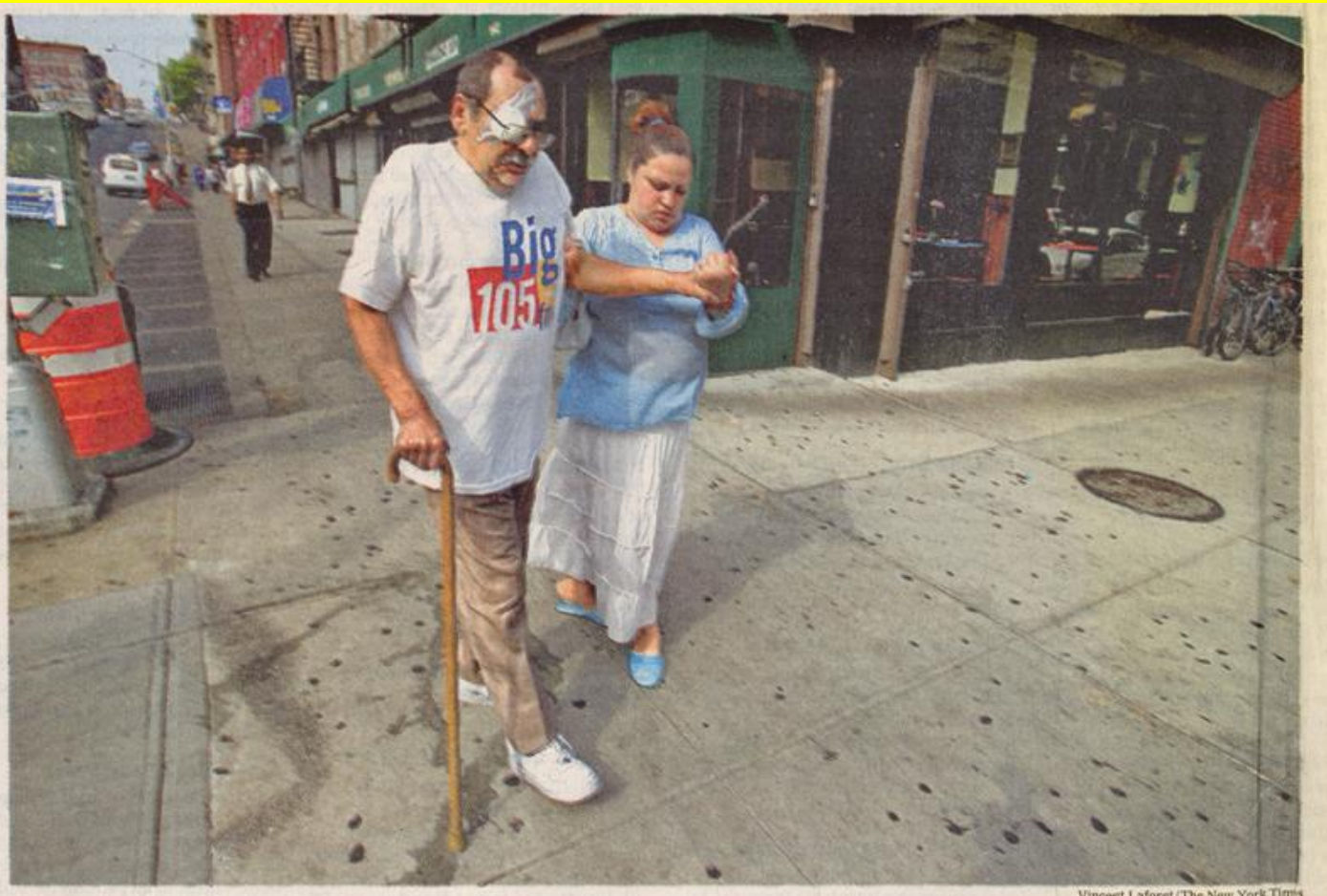
   A) Damage blood vessels- retina

   B) Eye lens swells (H_2O + glucose): blurred vision

Damaged blood vessels- diabetic retina (left)



Diabetes: East Harlem



Vincent Laforet/The New York Times

Santos Alicea and his daughter, Alicia Rodriguez, have Type 2 diabetes. The disease is ubiquitous in East Harlem, where they live.

Living at an Epicenter of Diabetes, Defiance and Despair

Health Risks

4. ↑ Kidney failure
5. Risk- **amputations**: toes, feet, legs (infections)

Vincent Laforet for The New York Times

Diabetes, soaring among New Yorkers, has already left a mark on Diane and Aniello Discala of the Bronx. She lost a leg to its complications.

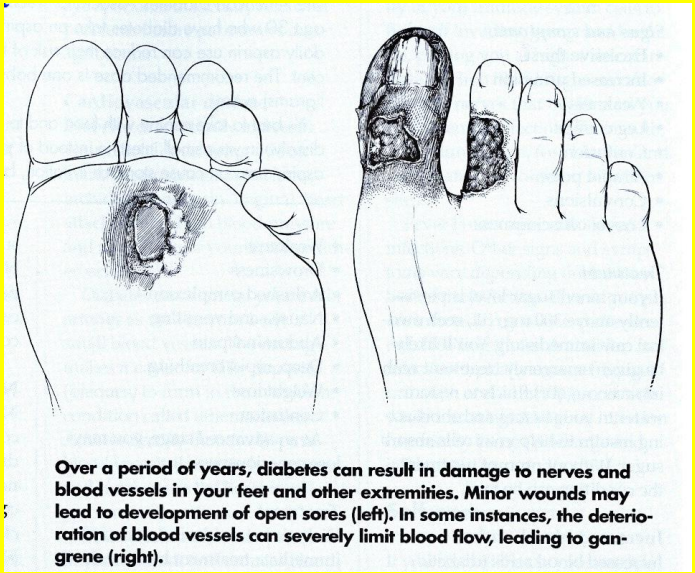
56 year old **diabetic** woman

- Admitted to hospital in shock
- Cyanosis (blue color) right fingers & toes: oxygen deficiency
- Amputation:

  right hand & foot

Health Risks

6. Nerve damage: numbness, tingling- feet
7. Infections- common: bacterial growth- gangrene



Over a period of years, diabetes can result in damage to nerves and blood vessels in your feet and other extremities. Minor wounds may lead to development of open sores (left). In some instances, the deterioration of blood vessels can severely limit blood flow, leading to gangrene (right).

Health Risks

8. Recurring infections: skin, gum, bladder (Type 2 diabetes)
9. Cuts & bruises slow to heal

What causes diabetes?

Diabetes: **3** types

Type 1

Type 2

Gestational

Type 1 Diabetes

- 5-10% of diabetics
- Can occur any age
- Most people: develops under 30
- Peak- girls: 10-12
- Peak-boys: 12-14

? Causes: Type 1

- Genetic pre-disposition
- ? Viral infection
- ? Exposure- toxins
- Autoimmune disease- body's immune system destroys its own Beta cells
- During this time: no symptoms
- **Slow destruction- Beta cells**

Omega-3's and Type 1 Diabetes

Children at risk Type 1 Diabetes:

Start 1 year old: ↑ omega 3 in diet

At age 6: ↓ 65% risk:

autoantibodies to pancreas Beta cells

Omega 3's may : ~~inflammation~~

Type 1 Diabetes

Type 1 Diabetes

- Result: **insulin deficiency**
- ↑ Blood glucose, but can't enter cells
- **"Starvation in midst of plenty"**
- Glucose spills- urine (wasted)
- Brain: not enough glucose
- Person: confused/lethargic, difficulty breathing

Type 1 Diabetes

- Without glucose, body breaks down (partially) **fat**- energy

ketones (acids)

- Brain, other tissues- adapt to use ketones for **energy**
- Excessive ketones → urine (test kit)

Type 1 Diabetes

- Ketones: ↑ acidity of blood **(ketoacidosis)**
- Rapid/deep breathing, very thirsty, urination, loss appetite
- **Fruity breath odor**
- Weakness, fatigue, confusion
- Severe dehydration, coma, death
- **Requires immediate treatment**

Atkins Diet & Ketones

- Induces ketosis (ketogenic diet): body uses up carbohydrate stores- breaks down fats → ketones
- Ketones: may reduce appetite
- In general: ketones produced if body doesn't get enough **carbohydrates**
- Burns fat for energy
- Similar to Type 1 diabetes

Concern: long-term effect:
Saturated fat & cholesterol, low fiber

- Example: ham, chicken, cheese & eggs in salad (induction phase)

Type 2 Diabetes

- More common form
- **90-95%** of diabetics
- **Insulin** at high levels
- Trying to get glucose into cells
- Muscle & adipose tissue cells not responding: "insulin resistance"
- Result: ↑ blood glucose

What causes Type 2 diabetes?

- Genetics & Lifestyle
- Genetics: If 1 identical twin gets diabetes, 2d also likely

You are at increased risk- Type 2 diabetes if:

- There is family history
- You are overweight (80% Type 2 diabetics are overweight)
- You have **abdominal obesity**
- However, also occurs in non-obese elderly

Risk: Type 2 Diabetes

- Usually occurs- people > 40
- Part of "metabolic syndrome"
- Symptoms develop **slowly** (people feel tired)

Risk: Type 2 Diabetes

- Today: ↑ seen in children & teens

Type 2 Diabetes: Underlying Cause

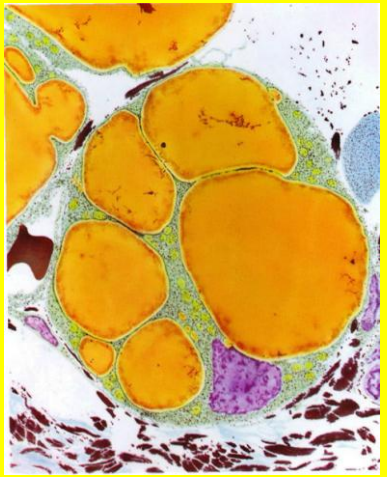
- Excess weight & fatty tissue

↓

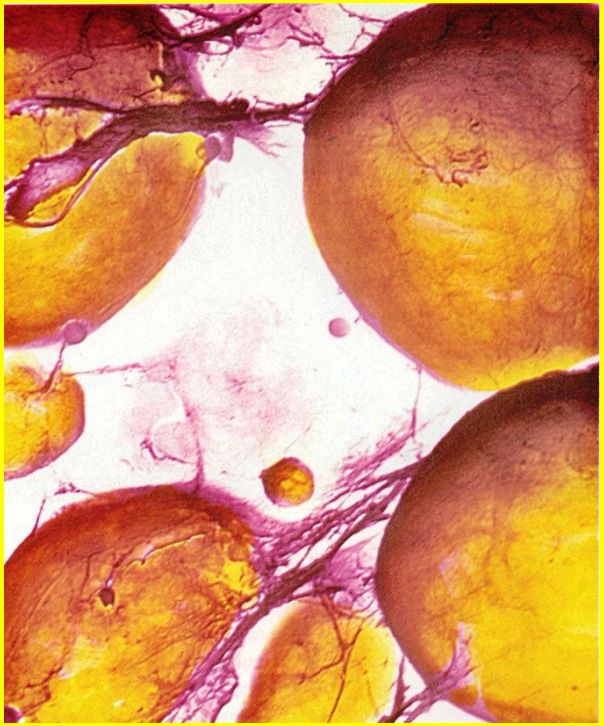
Insulin resistance

↓

Interfering with insulin receptor



- Overstuffed fat cells: leak fat & hormones (trigger inflammation): blood



- Fat → liver (fatty)
- Fat → muscle cells insulin resistance
- Fat → toxic: Beta cells

Pre-Diabetes

- 20 million adults
- **Asymptomatic**- may not know they have it
- Mildly high glucose: detected- routine screening (blood test)

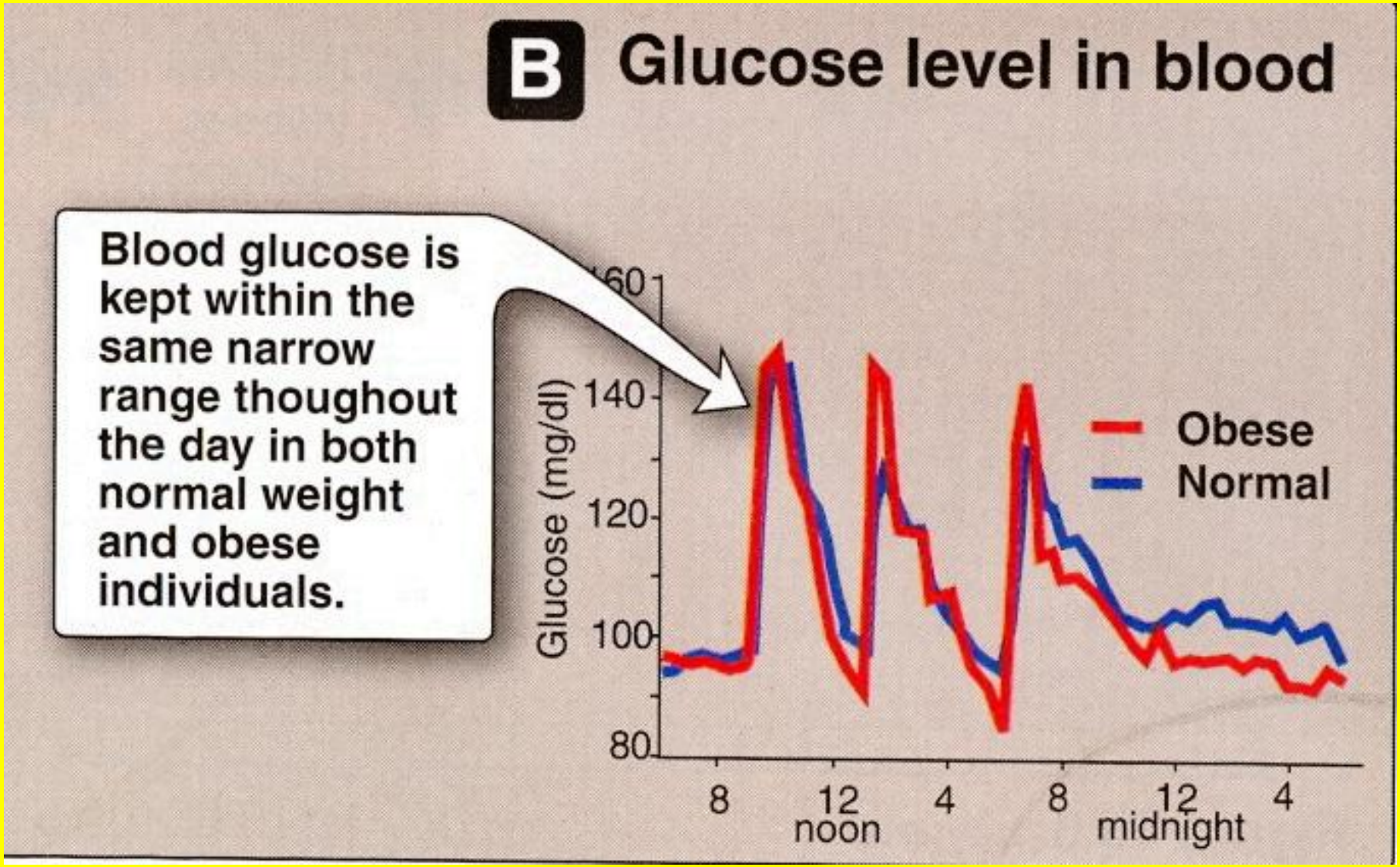
Pre-Diabetes → Diabetes

- But not always
- If: 1) weight loss
  2) exercise
  3) healthy diet

  Blood glucose may return to normal

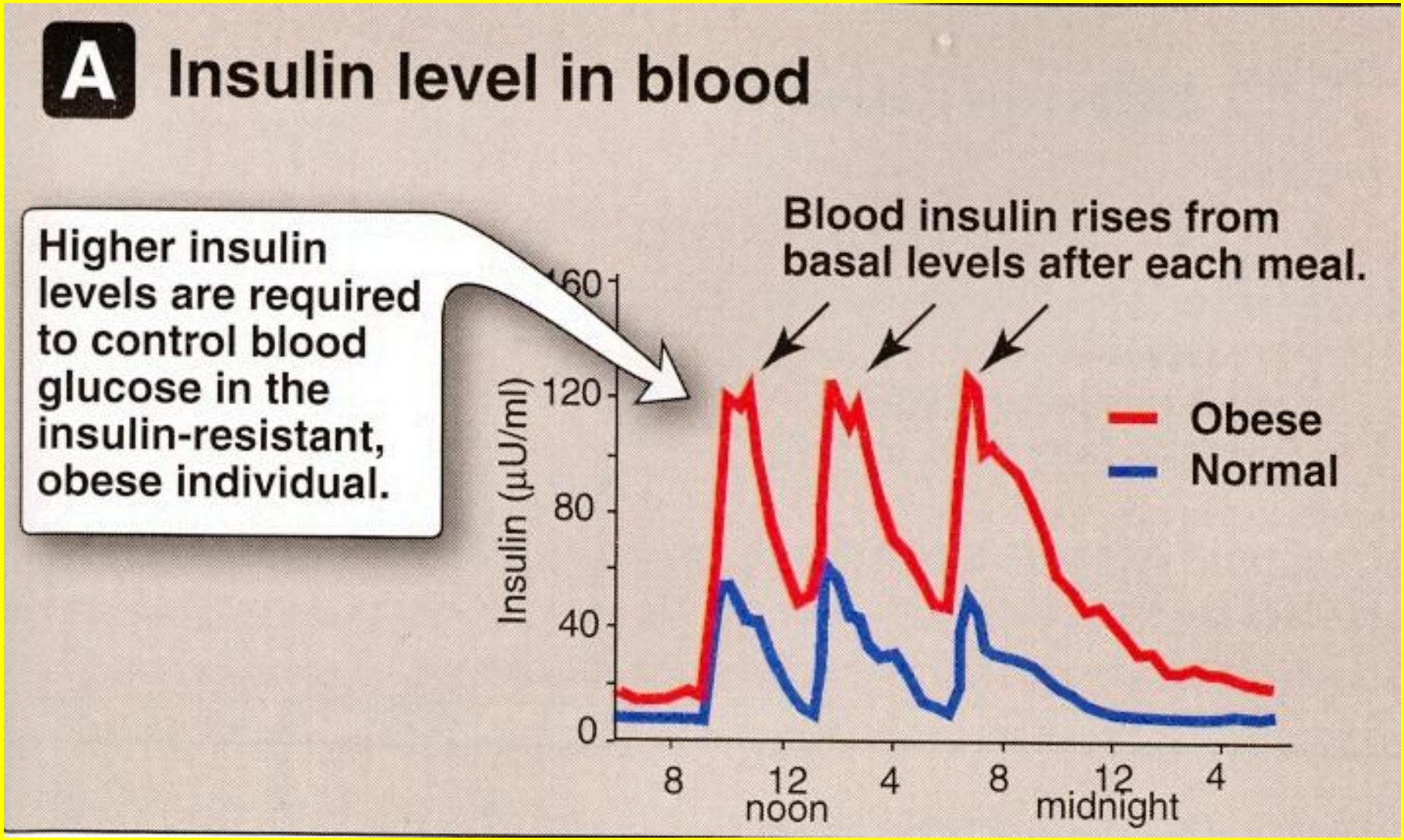
Pre-Diabetes: Way it starts

- **Initially obese person: same rise and fall in blood glucose during day as normal weight person**


B
Glucose level in blood
Blood glucose is kept within the same narrow range thoughout the day in both normal weight and obese individuals.
Glucose (mg/dl)
160
140
120
100
80
8
12
noon
4
8
12
midnight
4
Obese
Normal

Pre-Diabetes

- **Insulin resistance** develops
- **Behind the scenes: what's happening?**
- Obese person's pancreas-**pumping** out more insulin to compensate for resistance


A
Insulin level in blood
Higher insulin levels are required to control blood glucose in the insulin-resistant, obese individual.
Blood insulin rises from basal levels after each meal.
Insulin (μU/ml)
160
120
80
40
0
Obese
Normal
8
12
4
8
12
4
noon
midnight

- Fasting glucose starts to increase
- **10** years later- **diagnosis:** diabetes

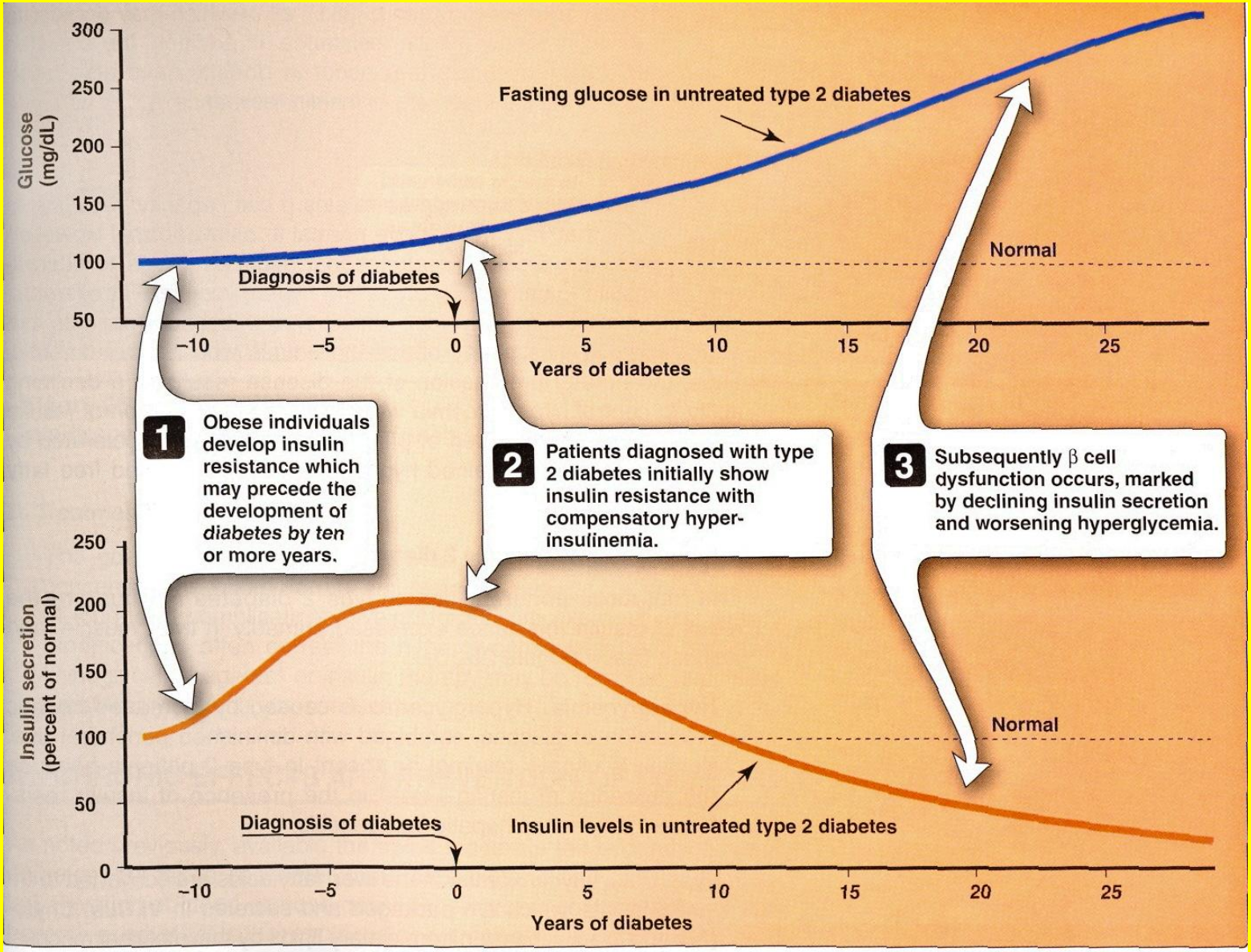


Figure 25.8
Progression of blood glucose and insulin levels in patients with type 2 diabetes.

- If untreated or blood glucose poorly controlled: **glucotoxicity**
- High glucose: toxic to Beta cells
- Beta cells become dysfunctional
- **"Beta cell fatigue"**
- Reduced secretion of insulin
- 40% Type 2 diabetics- need **insulin injections**

Beta Cell Fatigue

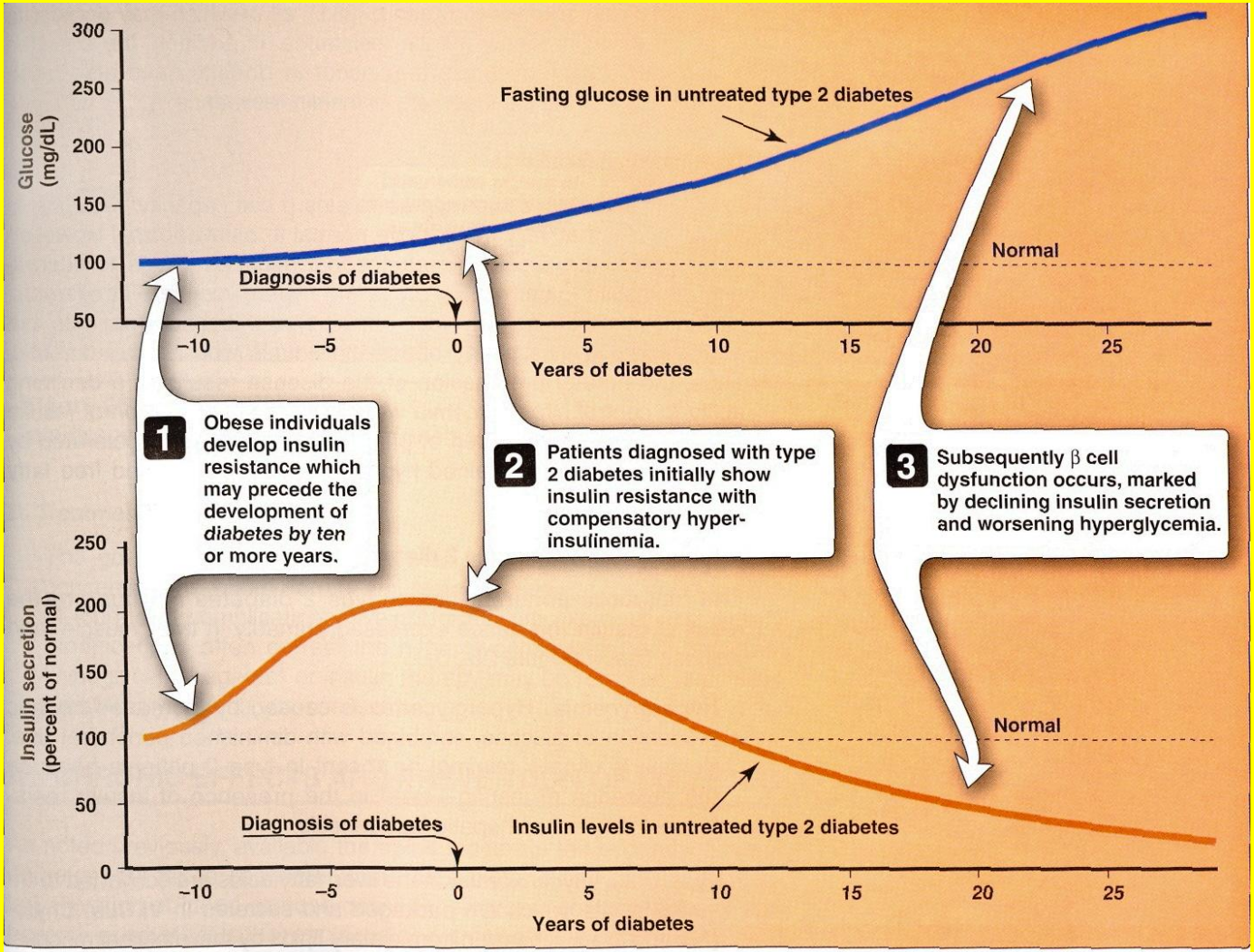


Figure 25.8
Progression of blood glucose and insulin levels in patients with type 2 diabetes.

- Type 2 Diabetes: further problem
- As insulin secretion ↓
- **Liver: ↑ glucose**

- Adds to high blood glucose problem

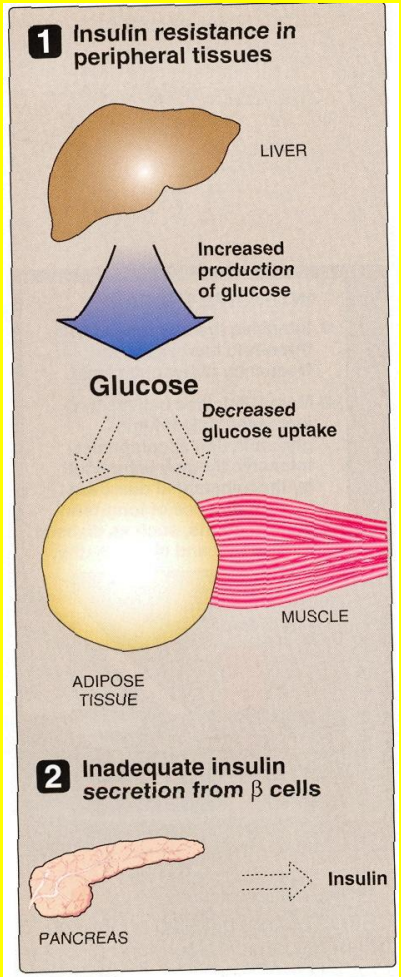


Figure 25.6
Major factors contributing to hyperglycemia observed in type 2 diabetes.

Summary: end result same for Type 1 & 2 Diabetics: High Blood Glucose

- Type 1: Beta cells destroyed,
  ↓ insulin, ↑ blood glucose
- Type 2: Cells not responding to insulin **("glucose intolerance")**
  Later ↓ insulin secretion
  Liver ↑ glucose release

Gestational Diabetes

- Gestation: period when fetus develops in uterus
- Some women during pregnancy:

  ↑ blood glucose
- Cause ? Pregnancy hormonal changes
- More common obese women

Gestational Diabetes

- Glucose mom's blood → placenta → fetus's blood
- Extra calories: **big baby**
- Delivery complications
- Poor glucose control:

↑ risk children obese at 5-7

Gestational Diabetes

- After pregnancy: diabetes disappears
- But mom at **risk**: Type 2 diabetes- later in life
- Treatment during pregnancy:

  A) carefully planned diet; B) moderate exercise; C) sometimes- insulin

Diagnosis of Diabetes

1. **Fasting (12 hour) glucose**
2. **Finger prick** screening- health fairs (126 milligrams or higher: concern)

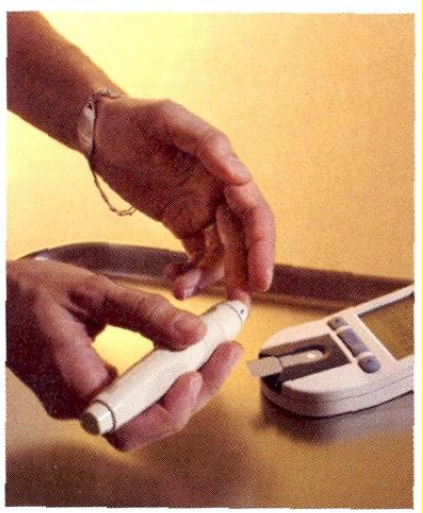


Figure 4.16 *Monitoring blood glucose requires pricking the fingers each day and measuring the blood using a glucometer.*

3. Glucose tolerance test
4. Hemoglobin A1C: glycosylated hemoglobin (HbA1C)
   a) red blood cells live ~ 120 days
   b) High amount glucose- sticks to red cell hemoglobin
   c) Measure HbA1C: tells how well glucose controlled for past months
5. Glucose in urine
6. Ketones in urine

Does eating diet rich in sugar cause diabetes?

- Answer: No
- But high intake sugar-rich foods/drink (excess calories) → obesity
- Fat gain ↑ risk Type 2 diabetes

How do you treat diabetes?

- Single most important thing: **control blood sugar** (toxic)
- Blood sugar monitoring 3-4 times/day if taking insulin
- Lancet,
  test strip,
  glucose monitor

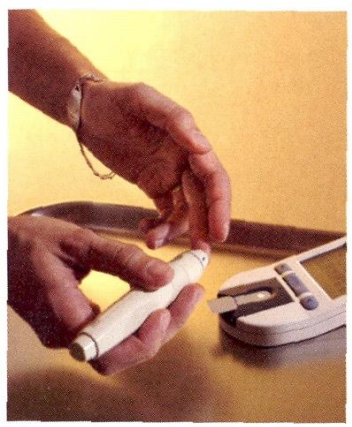


Figure 4.16 Monitoring blood glucose requires pricking the fingers each day and measuring the blood using a glucometer.

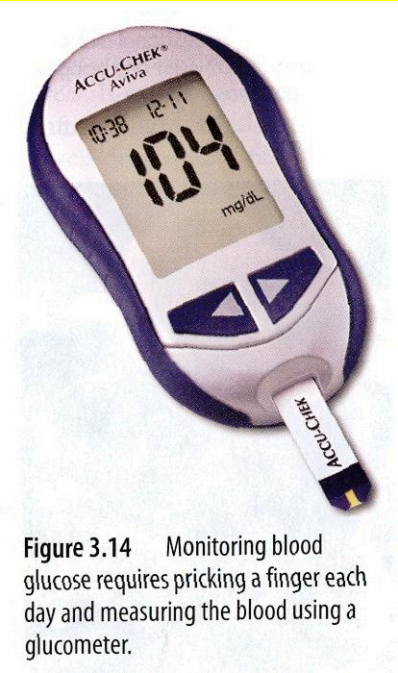
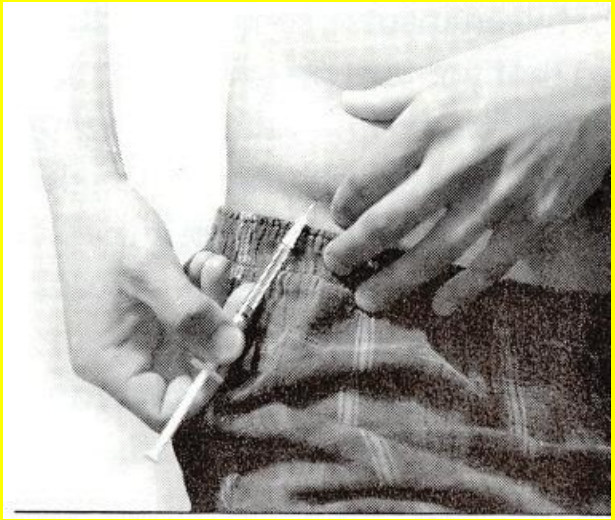


Figure 3.14 Monitoring blood glucose requires pricking a finger each day and measuring the blood using a glucometer.

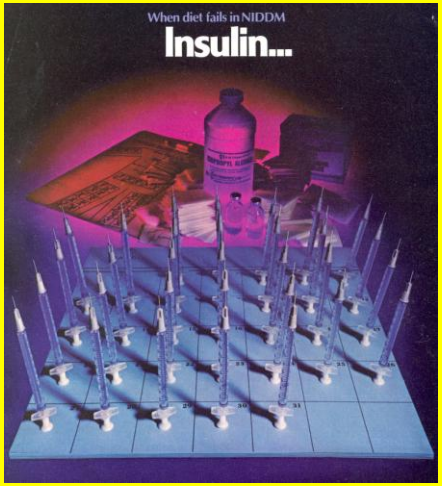
- Glucose monitoring: before meals & bedtime
- **Insulin injections**:

  All Type 1 Diabetics

  Some Type 2 Diabetics



Types of insulin



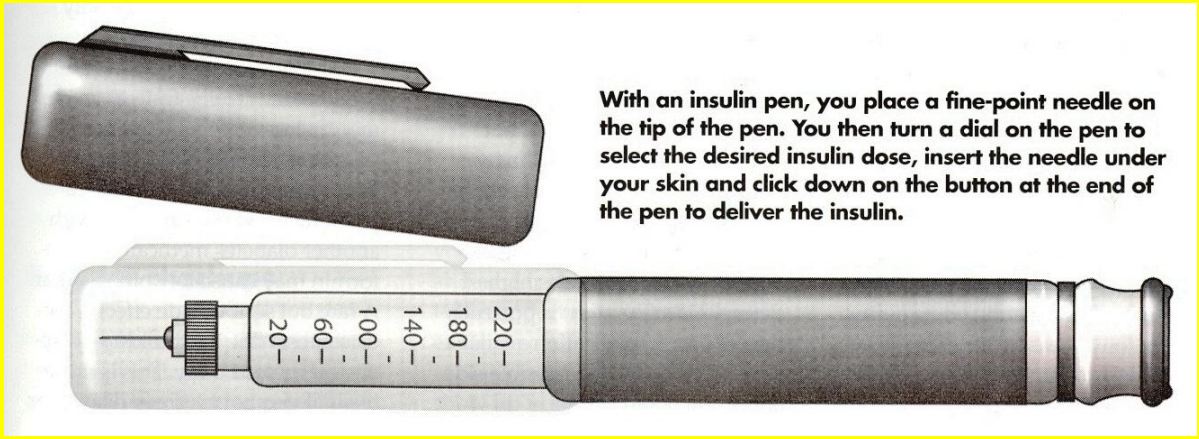
1. Long acting: once/day
2. Intermediate acting
3. Short (rapid) acting: before meals- prevents glucose spikes

<u>Trying to mimic how normal pancreas would release insulin throughout day</u>

Insulin Administration

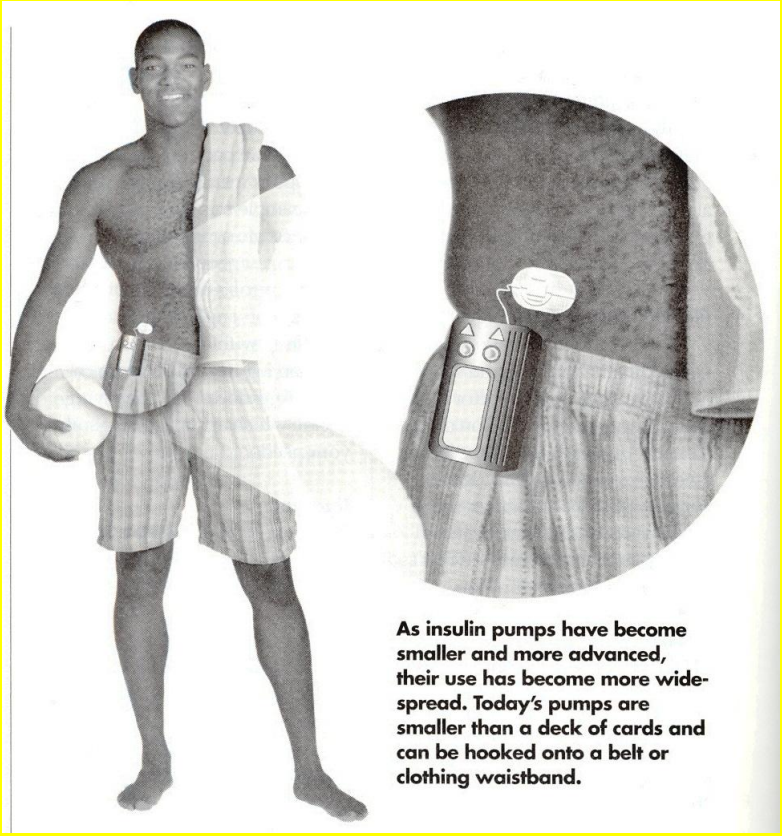
A. Syringe

B. Insulin pen



Insulin Administration

C. **Insulin pump**: insulin infusion (microprocessor) via catheter (under skin)



As insulin pumps have become smaller and more advanced, their use has become more widespread. Today's pumps are smaller than a deck of cards and can be hooked onto a belt or clothing waistband.

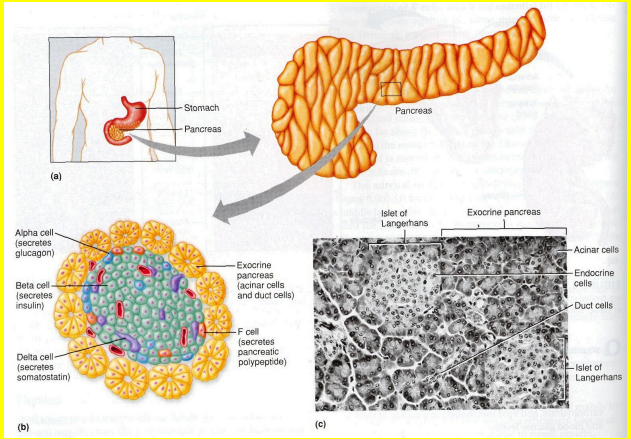
Insulin Administration

D. **Inhaled insulin** (powder form) approved by FDA 2006

- Developed by Pfizer
- For Type 1 & 2
- Type 1 still needs- long acting injections
- Banned- smokers: overdose problem

Treating Diabetes

- **Transplantation**: entire pancreas- cadaver
- No longer need insulin injections
- Problems: rejection
- Experimental procedure tested: transplant only Beta cells (islets)



Oral glucose lowering drugs

Treating Diabetes

- **Drugs:** Type 2 diabetics: different kinds/work different ways/combination therapies
  1. Stimulate pancreas: produce more insulin
  2. Decrease insulin resistance- help cells take up glucose
  3. ↓ Glucose release- liver
  4. Slow digestion carbs, slow increase blood sugar after meal

Insulin/Drugs/Food/Exercise

- **Coordination is key**
- Important: monitor blood/urine sugar
- Short-acting insulin or oral medication- before meal: controls blood glucose
- Important to eat something
- Otherwise: **hypoglycemia**

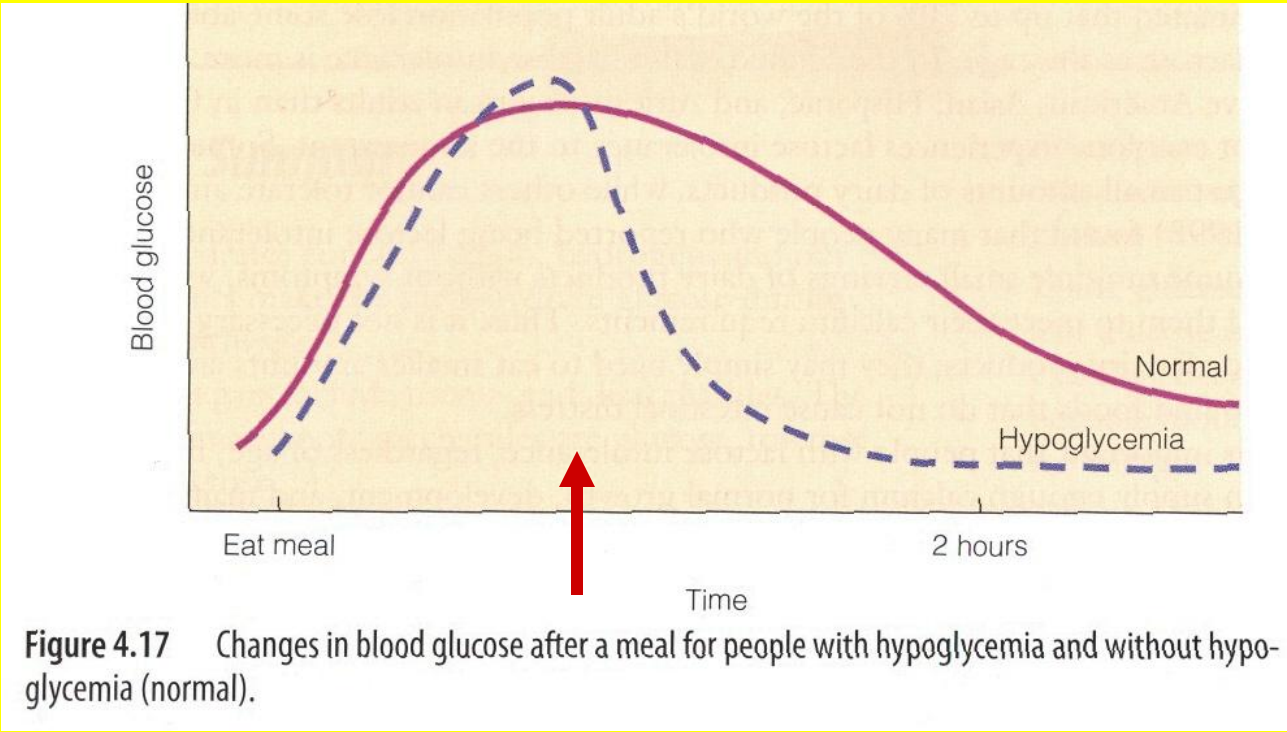


Figure 4.17 Changes in blood glucose after a meal for people with hypoglycemia and without hypoglycemia (normal).

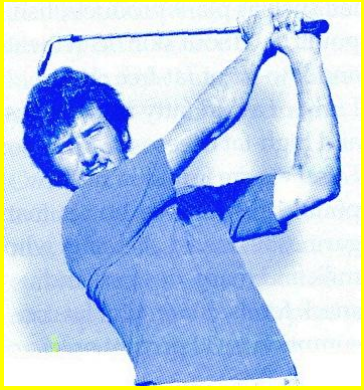
- Not good: 1 meal/day
- Better: Regular meals + snacks (without excess calories)

Hypoglycemia

- Have available: hard candy, glucose tablets
- Have available: glucagon emergency kit- injection- starts 5 minutes
- Wear medical alert bracelet/necklace

Exercise & diabetes

- During exercise: muscles use glucose for energy
- Result: drop- blood glucose
- Adjust insulin dose: type/amount/duration exercise



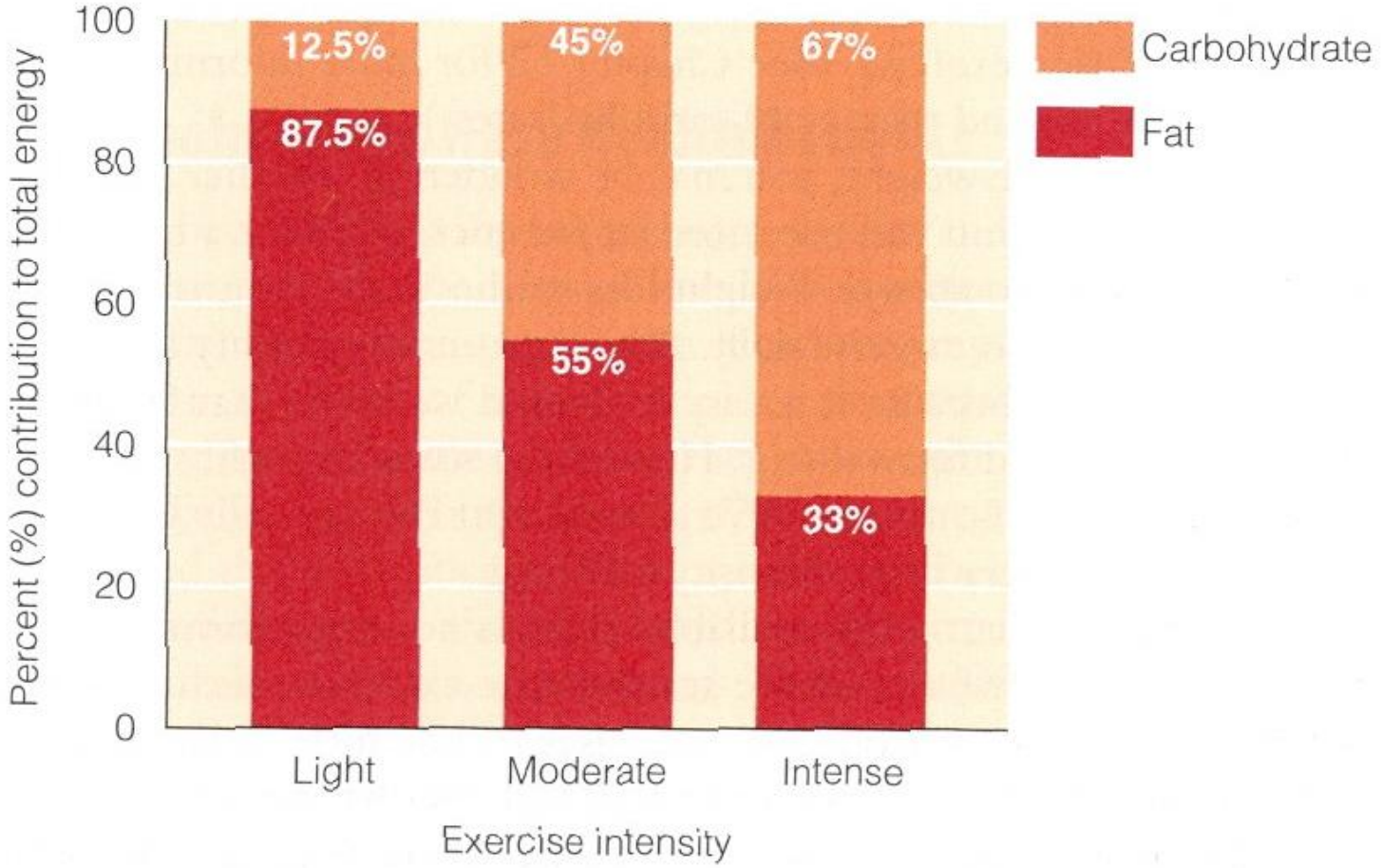


Figure 4.9 Amounts of carbohydrate and fat used during light, moderate, and intense exercise. (Adapted from J. A. Romijn, E. F. Coyle, L. S. Sidossis, A. Gastaldelli, J. F. Horowitz, E. Endert, and R. R. Wolfe. Regulation of endogenous fat and carbohydrate metabolism in relation to exercise intensity and duration. *Am. J. Physiol.* 265 (*Endocrinol. Metab.* 28) (1993): E380–E391.)

Diet & Diabetes

- Diabetics & non-diabetics: same recommendations- Dietary Guidelines
  - ↑ Fruits, veggies, whole grains, **fiber** (nutrient rich, low calories)
  - ↓ Fats, calories, sweets

Diet & Diabetes

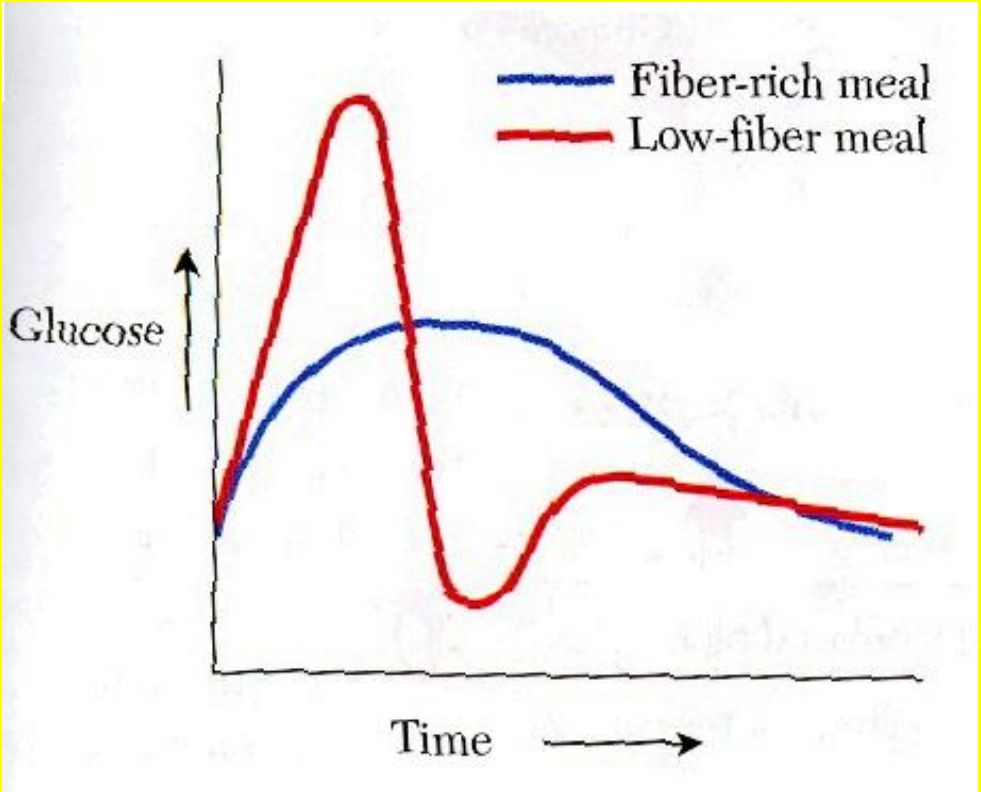
- Consistent routine- important: meals & snacks same amounts/regular times
- Better control blood glucose
- Carbs OK: need to be included in diabetic diet: whole wheat bread, fruits, veggies, low/nonfat milk products

Diet & Diabetes

- Sweets not forbidden if eaten with meal- but limit them
- Sweets alone sharp ↑ blood glucose
- Also: candy, soda, cookies: empty calories/few nutrients (Type 2 diabetic)

Diet & Diabetes

- **High fiber diet**: slows glucose absorption- intestine
- ↓ Insulin needed
- Better glucose control



Diet & Diabetes

- **Protein**: no need to limit

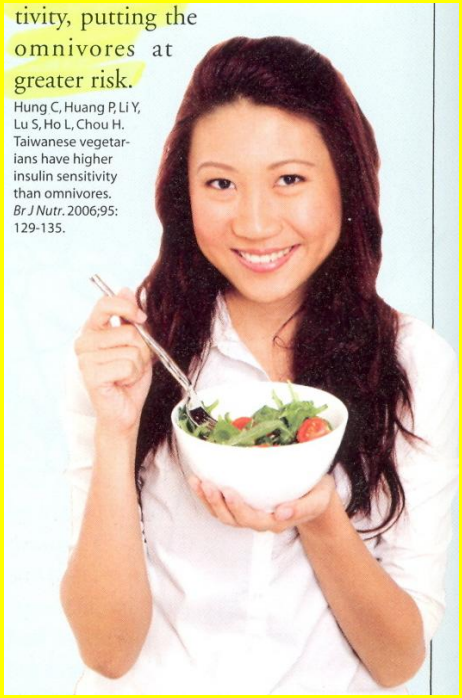
  15-20% total calories: low fat meat, chicken (no skin), milk, cheese, fish, peas, beans, soy products

- **Fats**: 30% total calories
- Limit saturated (animal) fat: 10% calories (7% for heart disease risk people)
- Cholesterol- 200 mg/day
- Salt- 2400 mg or lower
- Careful: ice cream/milk shakes- may have **added sugar**

Vegetarian diets & diabetes

- Vegetarians: greater insulin sensitivity
- 2006 study: low fat, vegetarian diet vs. ADA guidelines (Type 2 diabetics):

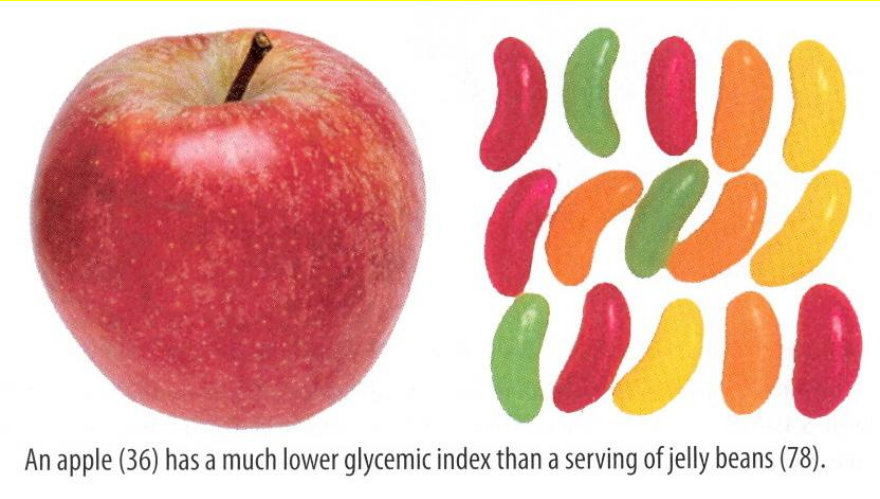
↓ blood glucose
↓ weight
↓ BMI
↓ LDL



pcrm.org/diabetes

Glycemic Index (GI)

- Different carbs raise blood glucose different ways
- Reference: compare foods to **glucose**: value set at **100**



An apple (36) has a much lower glycemic index than a serving of jelly beans (78).

- High glycemic index foods:
  - Sharp ↑ blood glucose
  - Large ↑ insulin needed
  - Bad for diabetic
- Low glycemic index foods- more moderate increases- blood glucose
- In general: low glycemic index foods- better for diabetic: ↑ HDL, better control glucose

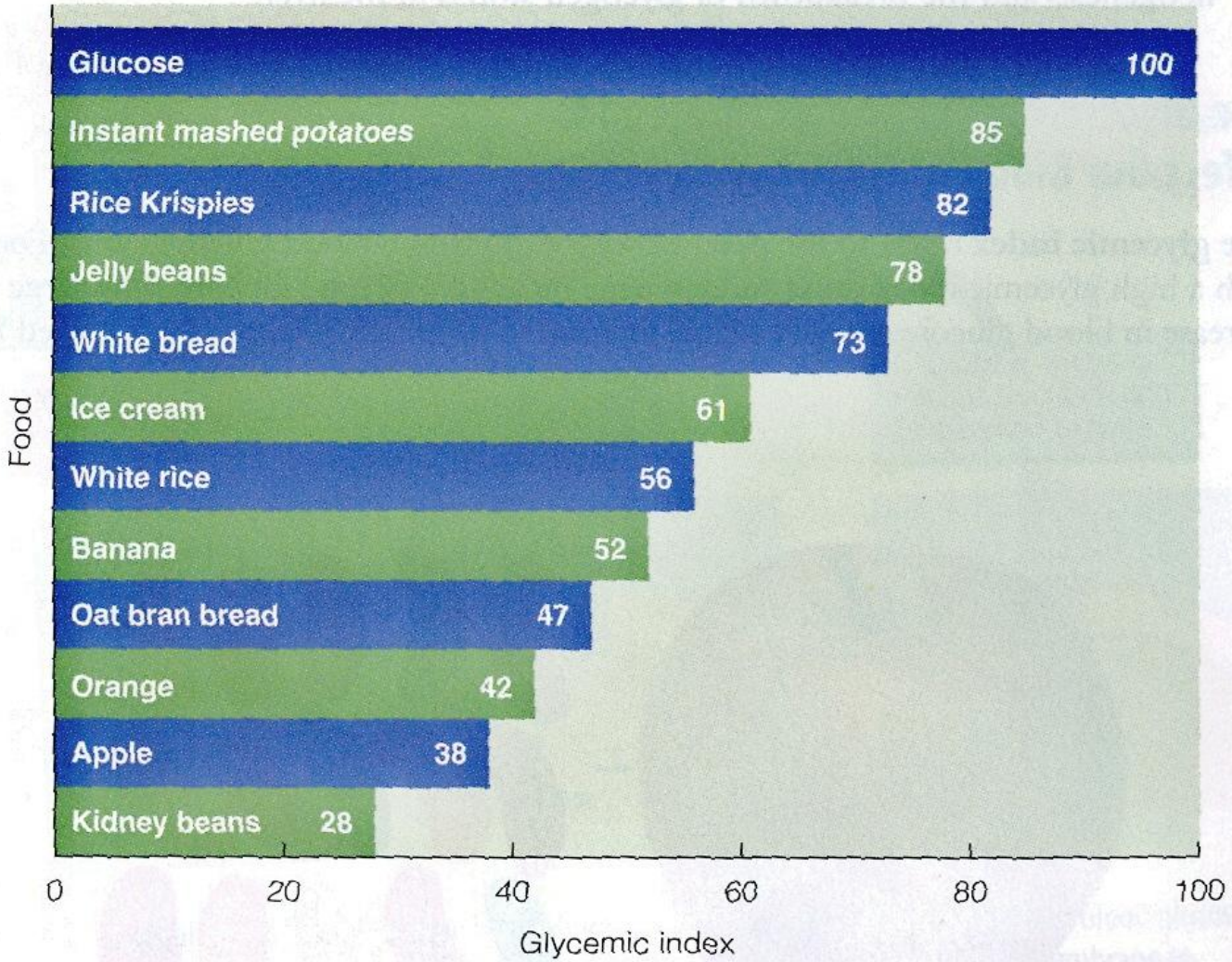


Figure 4.8 Glycemic index values for various foods as compared to pure glucose. (Values derived from K. Foster-Powell, S. H. A. Holt, and J. C. Brand-Miller. International table of glycemic index and glycemic load values. *Am. J. Clin. Nutr.* 76 (2002): 5–56.)

- Problem: foods seldom eaten alone- usually part of meal
- Fat & protein foods- leave stomach slowly, slow glucose rise in blood

FIGURE 4.23 *High-carbohydrate foods like baked potatoes are not high in kcalories, but the toppings used on them often are.* (FoodCollection/IndexStock)

- Example: if you drink soda, blood glucose ↑ in minutes
- If you eat chicken, brown rice, beans: 30-60 minutes ↑ blood glucose

Confusing glycemic index foods

Food	**GI**
Potatoes (complex)	85
Apple (sweet)	38
Chocolate fudge cake	41
100% whole grain bread	62

- Newer idea: **Glycemic Load**=

  Multiply glycemic index (how fast blood glucose increases) X amount of carb in one serving
- Some scientists question value of GI, GL
- May be better for fine-tuning diet
- Better concept: eat less refined carbs, more whole grain carbs

No Calorie Sweeteners

- Contain small amount calories (<5 calories/serving)
- Generally safe if used in small amount
- Only need a little

  to make food/drink sweet

Contrary to recent reports claiming severe health consequences related to consumption of alternative sweeteners, major health agencies have determined that these products are safe for us to consume.

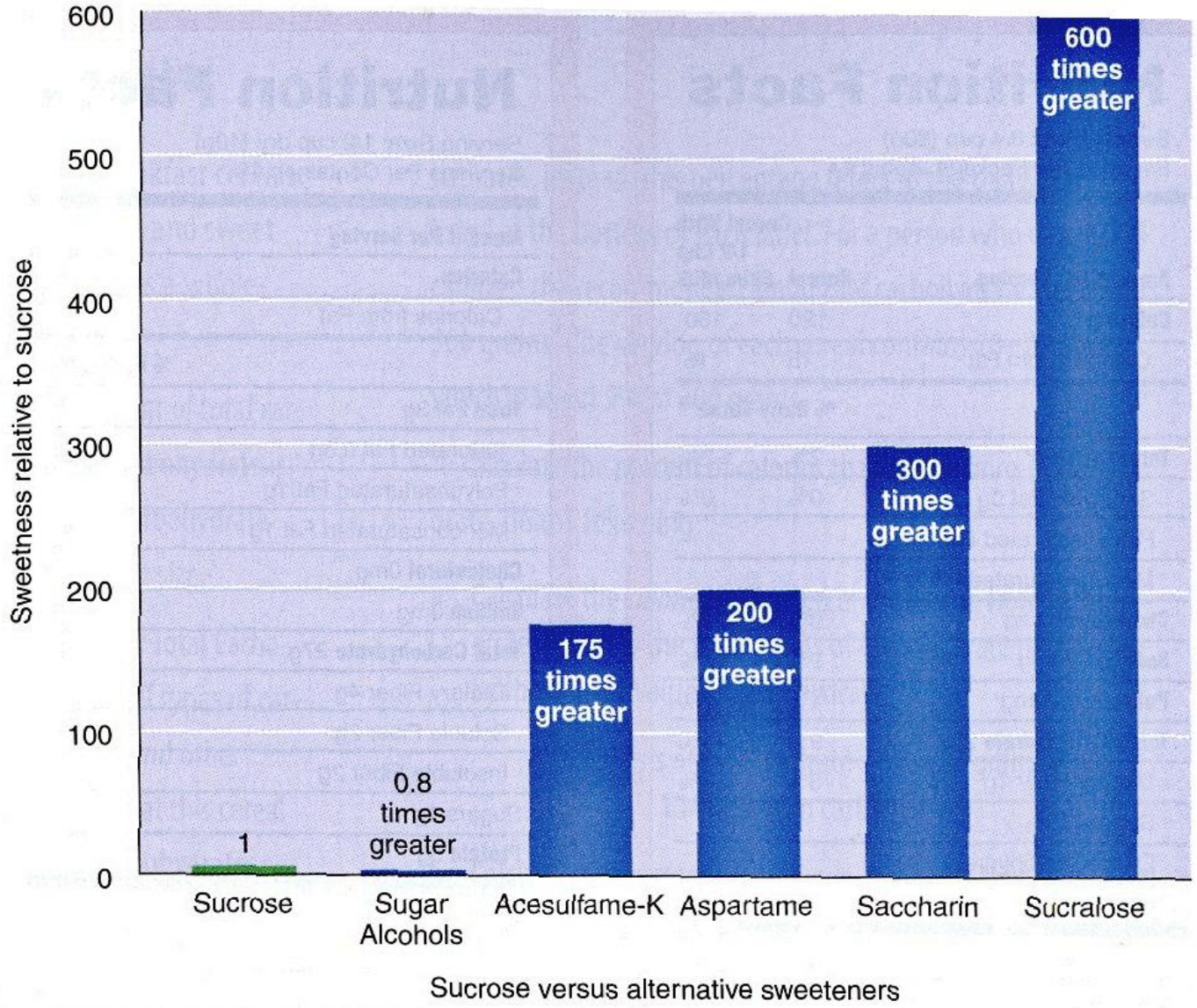


Figure 4.14 Relative sweetness of alternative sweeteners as compared to sucrose. (Values derived from International Food Information Council. Food safety and nutrition information. Sugars & low-calorie sweeteners. http://ific.org/food/sweeteners/ Accessed July 2003).

- Examples:

  Aspartame (Equal, Nutrasweet)

  Splenda (sucralose)

  Saccharin
- Found: sugar-free products
- May be helpful: people trying to lose weight

Diabetes & Alcohol

- Avoid alcohol- empty stomach
- Causes sharp ↑ blood glucose
- If diabetic drinks: do so with snack/meal
- Limit consumption:

  2 drinks/day (men)

  1 drink/day (women)

- 1 drink: 12 oz beer, or 5 oz wine, or 1.5 oz distilled spirits

Coffee & Diabetes

Starting at **3** cups/day: see reduced risk Type 2 Diabetes

Mechanisms?

Magnesium & Diabetes

↑ magnesium foods

↑ insulin sensitivity

↓ risk type 2 diabetes

African American/Hispanic diabetics: low magnesium in blood

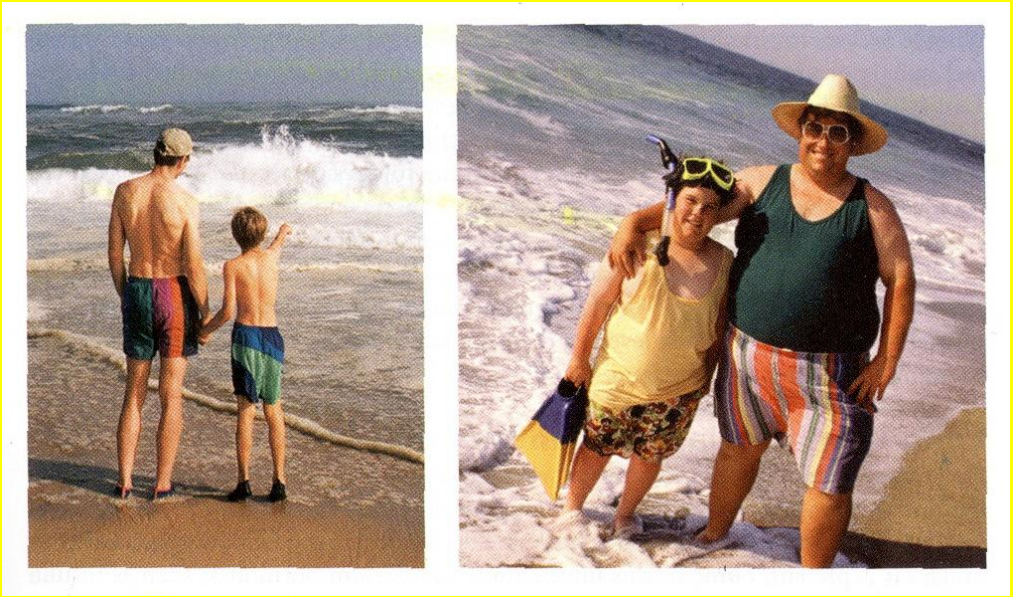
Magnesium rich foods (50-150 mg)

- Pumpkin & squash seeds
- Nuts/peanuts
- Bran cereal
- Halibut
- Quinoa
- Spinach
- Beans
- Pollock
- Bulgur
- Oat bran
- Tuna
- Artichokes

Almonds Considered by many to be the most nutritionally balanced nut, almonds are a good source of protein, vitamin E, and selenium.

Physical activity & weight control

- Type 1 diabetic: typically at or below ideal weight
- Type 2 diabetic: majority overweight



Weight control: of critical importance

Why?

↑ Fat deposits in body

↑ Insulin Resistance

↑ Diabetes Risk

Weight loss: Type 2 diabetics by:

↓ calories ↑ exercise

Benefits: reduced use of drugs for diabetes, blood lipids, blood pressure

↓ Blood pressure, triglycerides

↑ HDL

Type 2 Diabetes: What's best advice?

- Key: Prevention
  - ↑ Exercise
  - ↓ Modest weight loss
  - ↑ Whole grains/fiber
  - ↑ Fruits & veggies
  - ↓ Fat intake