Exercise Basics: Getting Active with T1D

Jane Yardley, PhD

UNIVERSITY OF ALBERTA
AUGUSTANA CAMPUS

Learning Objectives

- By the end of this session you should be able to:
  - Explain where fuel is stored in the body
  - List the main types of exercise and their preferred source of fuel
  - Describe the difference between natural and synthetic insulin and their impact on blood glucose during exercise
  - Discuss potential insulin adjustments and carbohydrate intake for exercise

Why Exercise?

- People with type 1 diabetes who exercise regularly will:
  - Live longer
  - Have a lower risk of heart disease
  - Develop fewer complications
  - Maintain healthier body weight
  - Maintain more lean body mass and bone mineral density
  - Be happier (self-rated QOL)
  - If a pill did all of this, wouldn't you take it every day?

Why Don’t People Exercise?

- Top reasons for not exercising generally include:
  - Lack of time
  - Lack of money
  - Lack of knowledge
  - Lack of results
  - Lack of enjoyment

- With type 1 diabetes:
  - Fear of hypoglycemia generally trumps all of these

Fueling the Body

Food

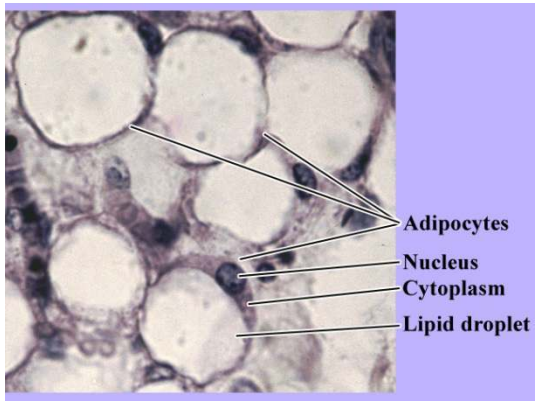
Carbohydrate, lipid (fat), protein

ATP

Muscle contraction

Where is the Energy Stored?

- Lipids (fat)
  - Adipose tissue (97.53%)
  - Muscle (2.43%)
  - Blood (0.04%)
- Carbohydrate (glucose)
  - Muscle (79.52%)
  - Liver (19.88%)
  - Blood (0.60%)



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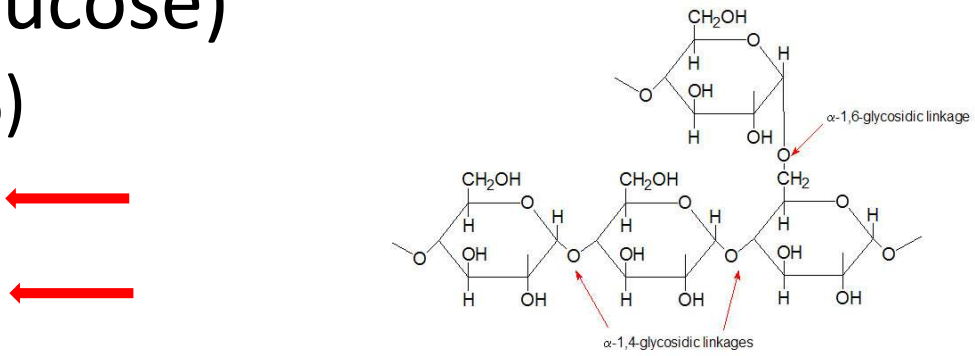


http://themedicalbiochemistrypage.org/carbohydrates.html

How does it get there?

- Glucose
  - Preferred source of fuel for the brain and nervous system
  - Relatively large molecule (needs help to get into cells)
  - “Glut” transporters help glucose get into the cell
  - The Glut-4 transporters, found in muscle, liver, and fat cells
  - Glut-4 transporters are “activated” by insulin
  - Note for later: Glut-4 transporters are also activated by muscle contraction (without insulin being present)

How does it get there?

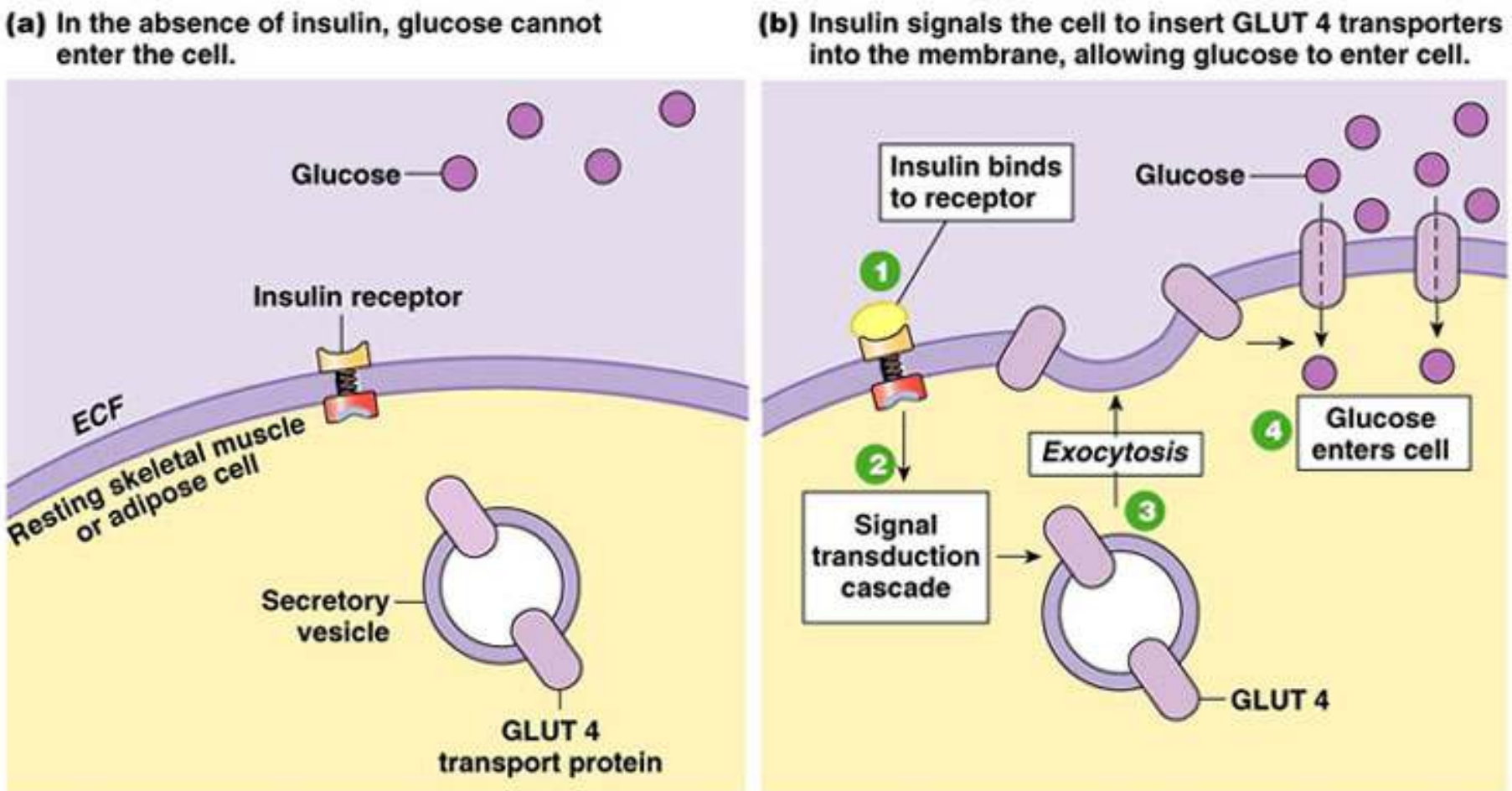
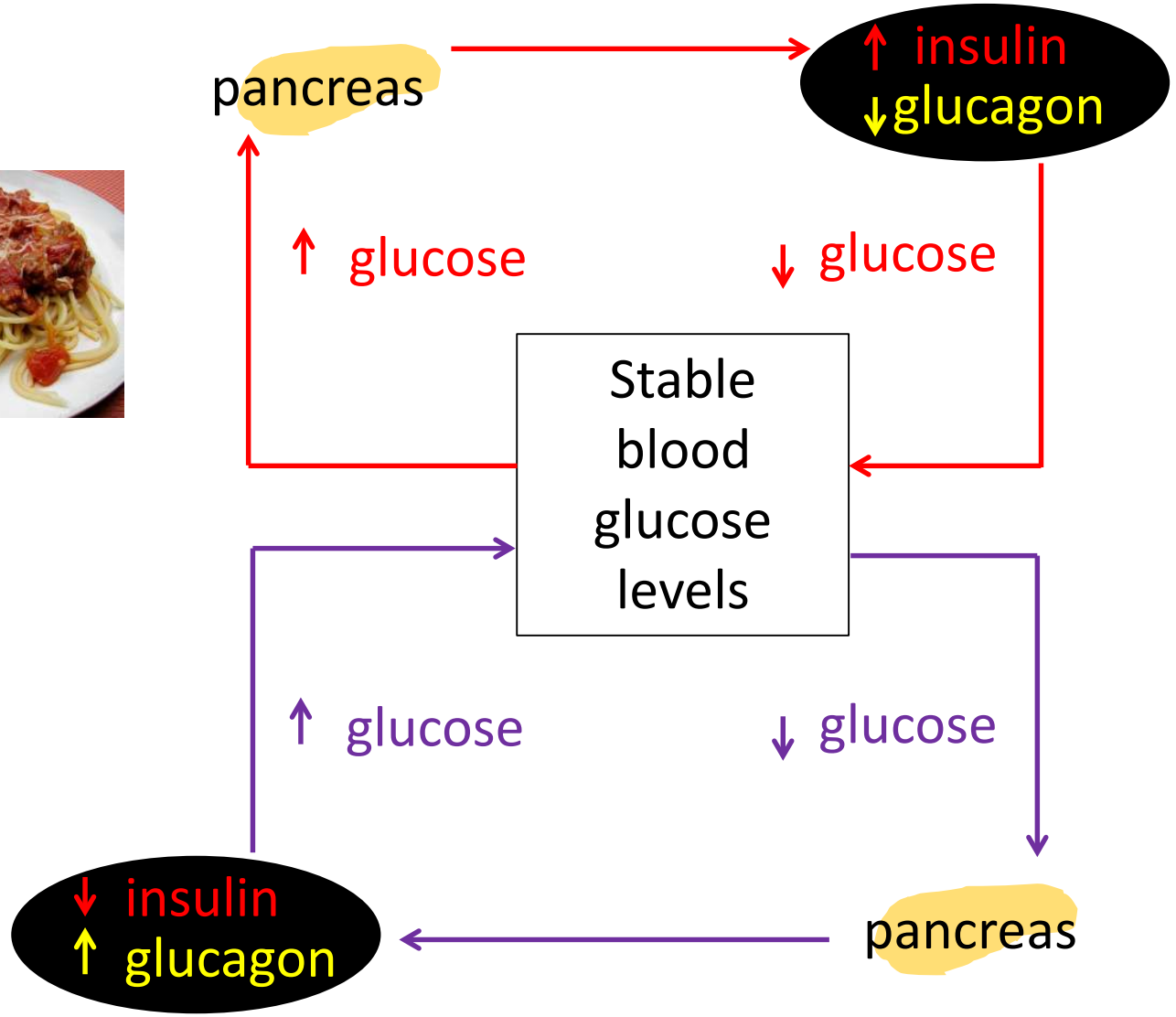


Fig. 22-12

Energy Systems

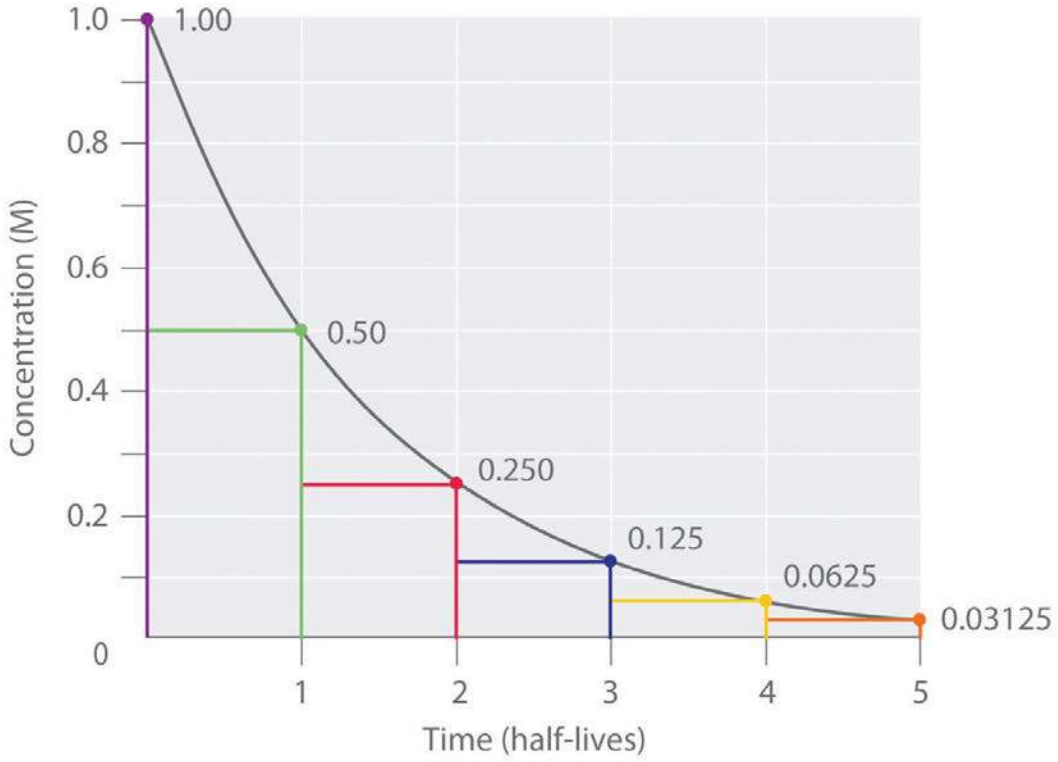
- Insulin: helps store glucose (muscle, liver, fat cells)
- Glucagon: helps release energy from storage (liver) on demand (fasting or exercise)
- Both are normally released by the pancreas
- Circulating insulin prevents release of glucagon

Keeping the Balance



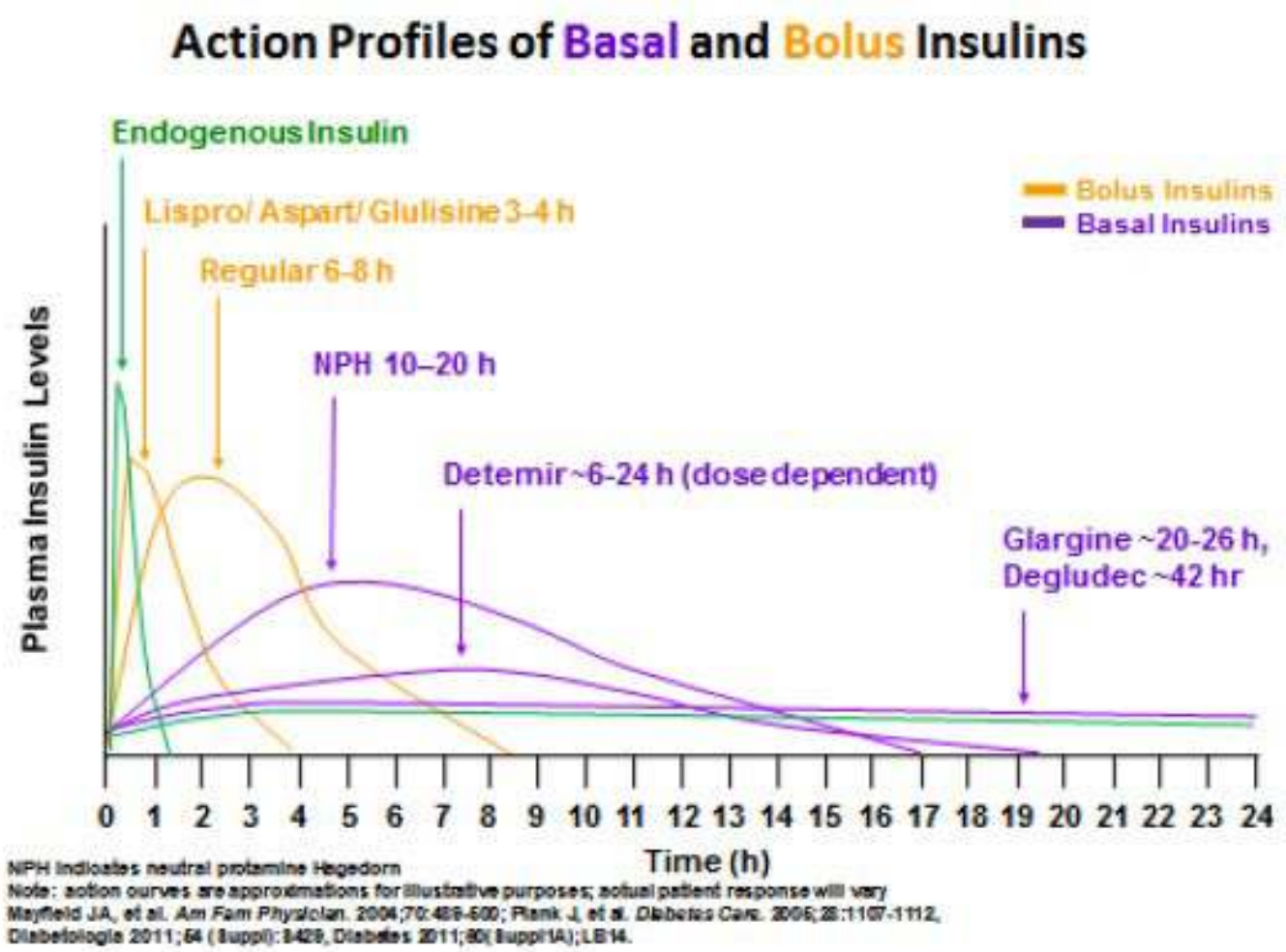
Insulin

- Naturally produced (endogenous) insulin
  - Made by beta cells of the pancreas
  - Half-life ~ 5-7 minutes
- Synthetic insulin
  - Delivered by pump/injection
  - Different durations
    - Very short acting (0.2 to 2 hours)
    - Long acting (up to 36 hours)

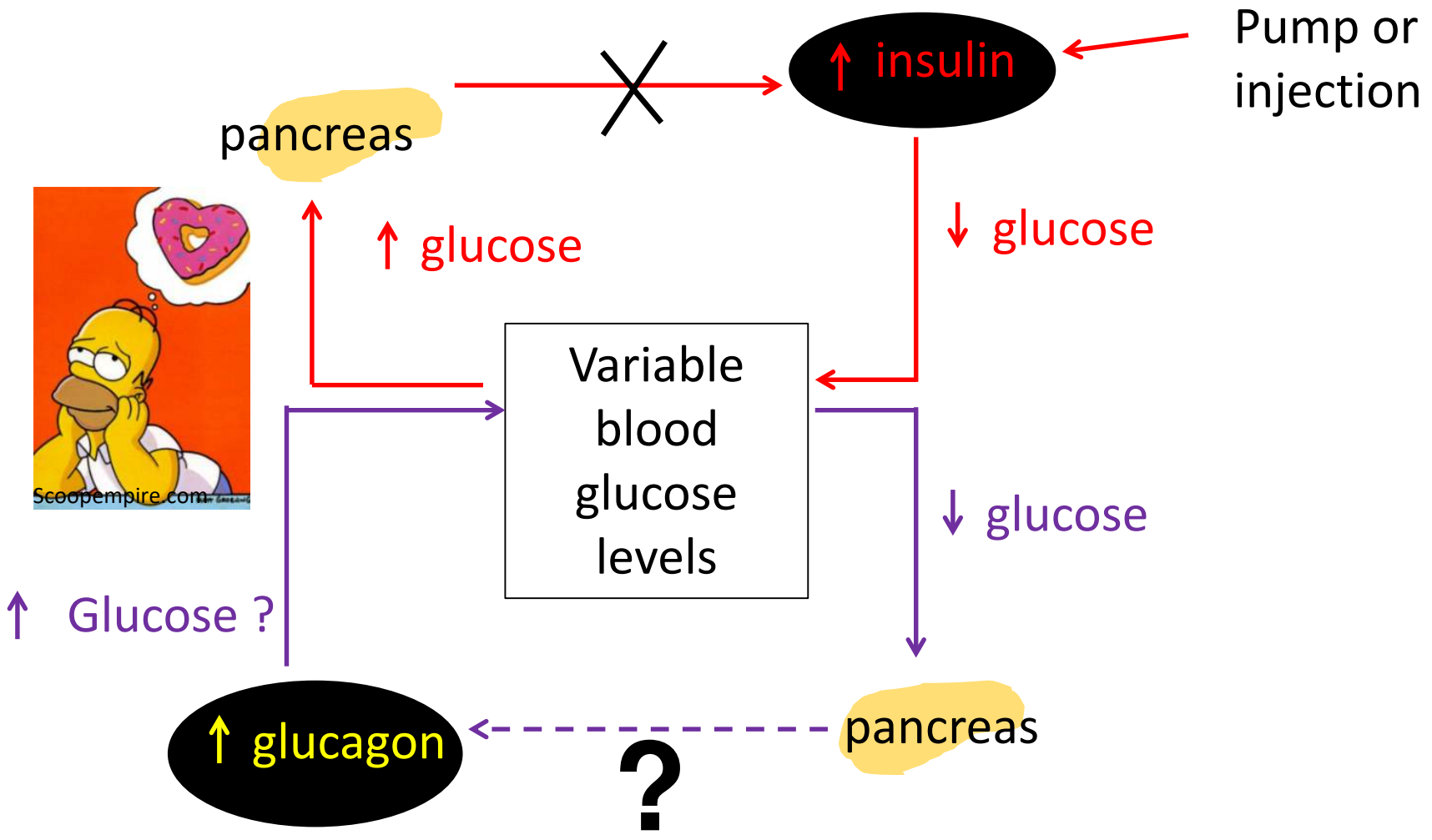


chem.libretexts.org

Insulin


Action Profiles of Basal and Bolus Insulins
Endogenous Insulin
Lispro/ Aspart/ Glulisine 3-4 h
Regular 6-8 h
NPH 10–20 h
Detemir ~6-24 h (dose dependent)
Glargine ~20-26 h,
Degludec ~42 hr
Bolus Insulins
Basal Insulins
Plasma Insulin Levels
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time (h)
NPH indicates neutral protamine Hagedorn
Note: action curves are approximations for illustrative purposes; actual patient response will vary
Mayfield JA, et al. Am Fam Physician. 2004;70:489-500; Plank J, et al. Diabetes Care. 2005;28:1107-1112.
Diabetologia 2011;54 (Suppl):S428, Diabetes 2011;60(SupplA);LB14.

Keeping the Balance with Type 1 Diabetes



Putting it all into Context with Exercise

Types of Exercise / Physical Activity

- Aerobic exercise
  - Repeated, rhythmic contraction of large muscle groups (usually for at least 10 minutes)
  - Breathing is deep, but conversation is usually possible
  - Includes dancing, swimming, cycling, jogging, walking, etc.
  - Don’t forget: vacuuming, gardening, scrubbing floors, snow shovelling….
- Anaerobic exercise
  - High intensity exercise
  - Contractions are powerful/fast enough that the body is unable to supply enough oxygen
  - Includes sprints, plyometric exercises, weight lifting, etc.

Where is the Energy Stored?

- Lipids (fat)
  - Adipose tissue (97.53%)
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  - Blood (0.04%)
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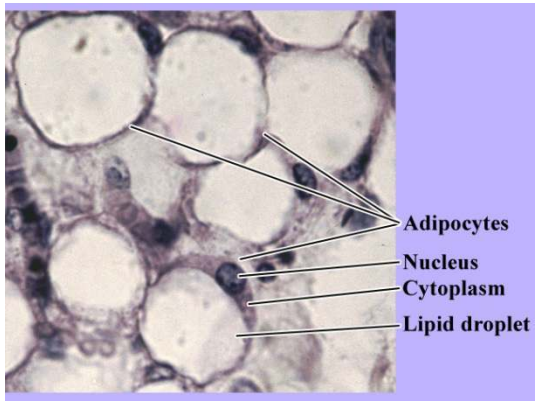

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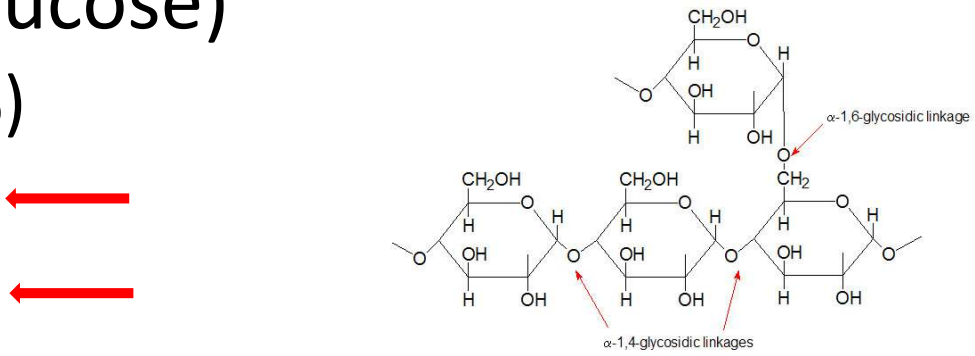


http://themedicalbiochemistrypage.org/carbohydrates.html

Fuel Sources for Aerobic Exercise

Type of Fuel	Storage Area
#1: Fat	Adipose Tissue
#2: Glucose	Blood Glucose
#3: Amino acids	Muscle

4 – 10 mmol/L
(~ 1 tsp)

Key hormones: Insulin and glucagon

“Aerobic” exercise – body can supply enough oxygen to fully convert glucose/fat to ATP

Keeping the Balance

pancreas

↑ insulin
↓glucagon

↑ glucose

↓ glucose

Stable
blood
glucose
levels

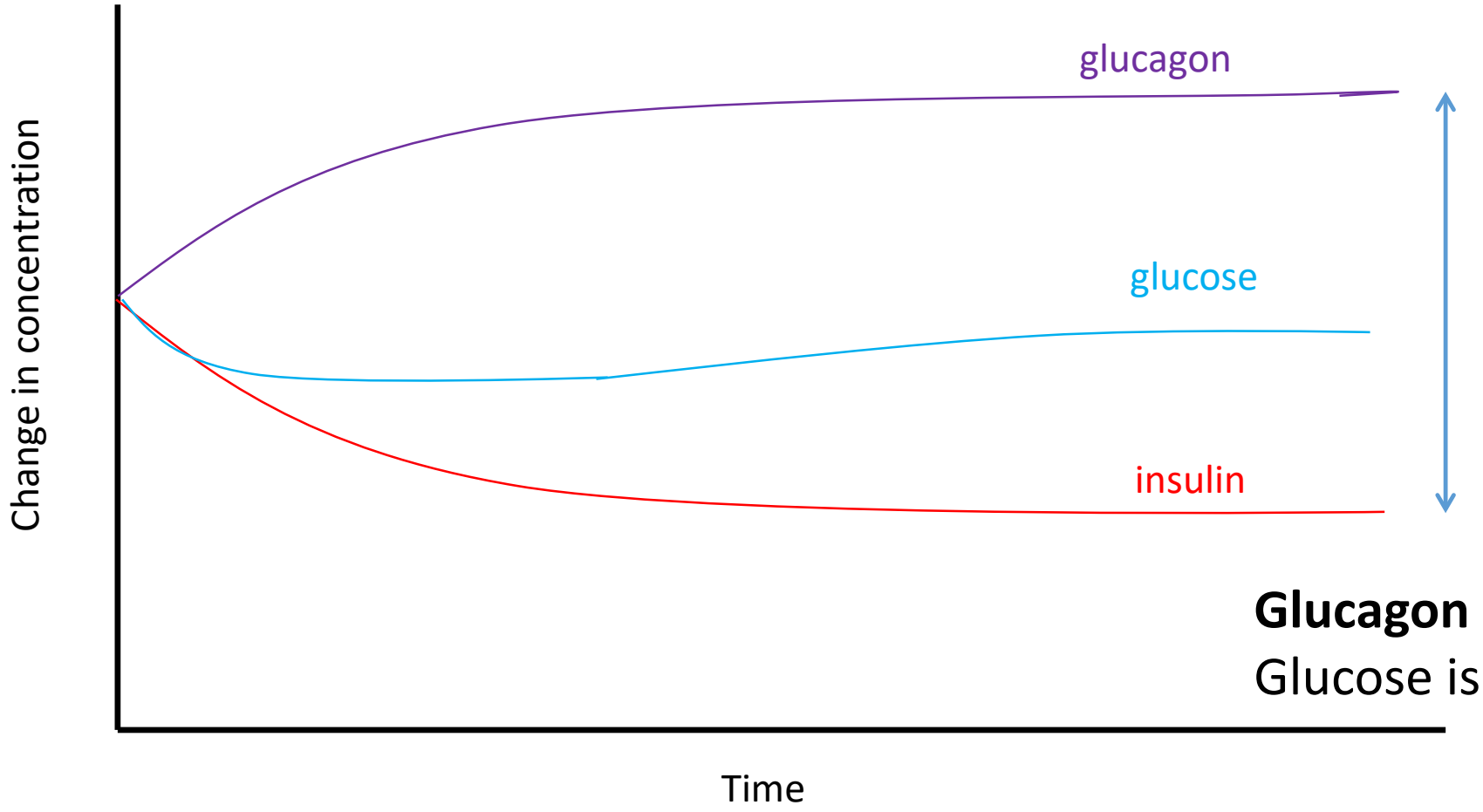
↑ glucose

↓ glucose

↑ glucagon
↓ insulin

pancreas

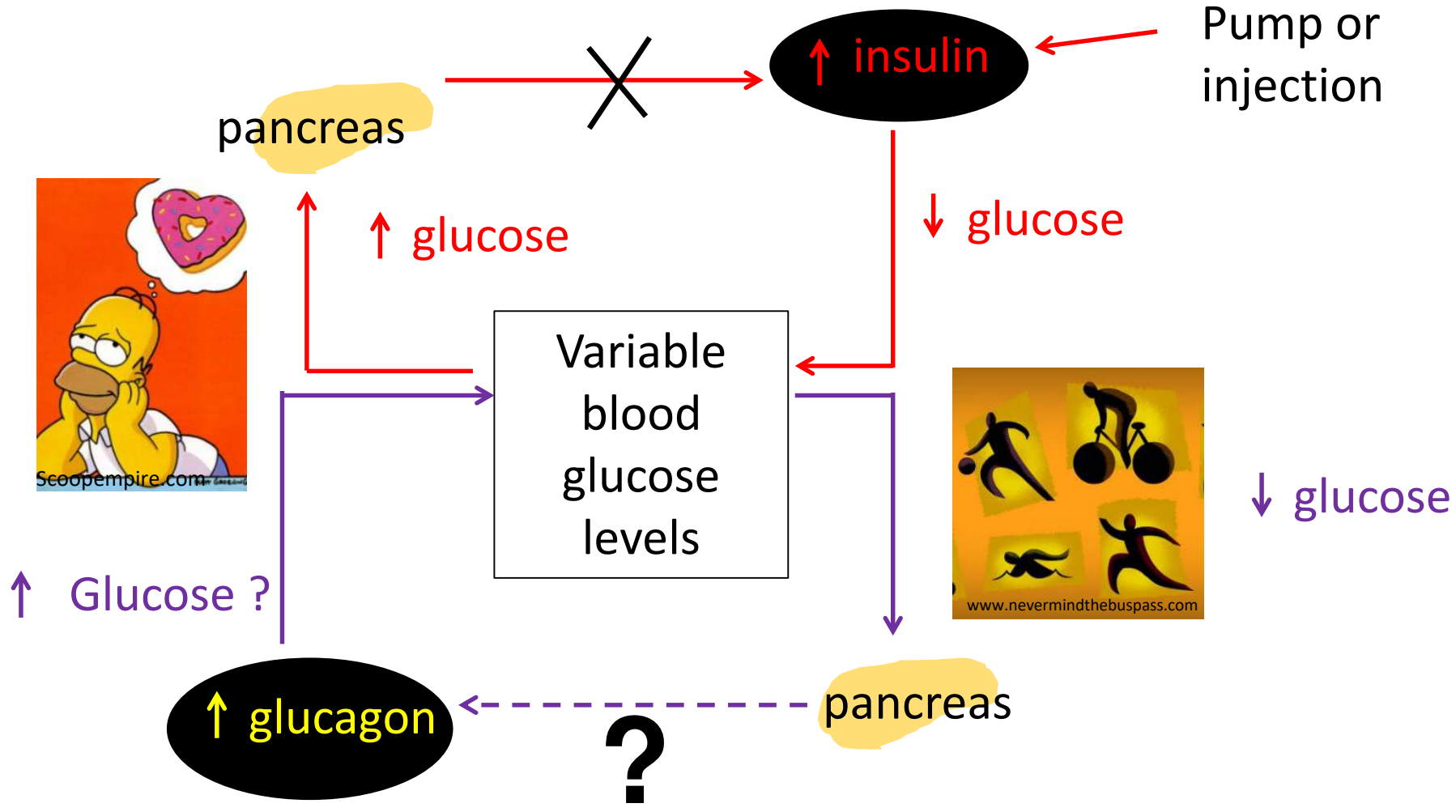
Aerobic Exercise without Type 1 Diabetes



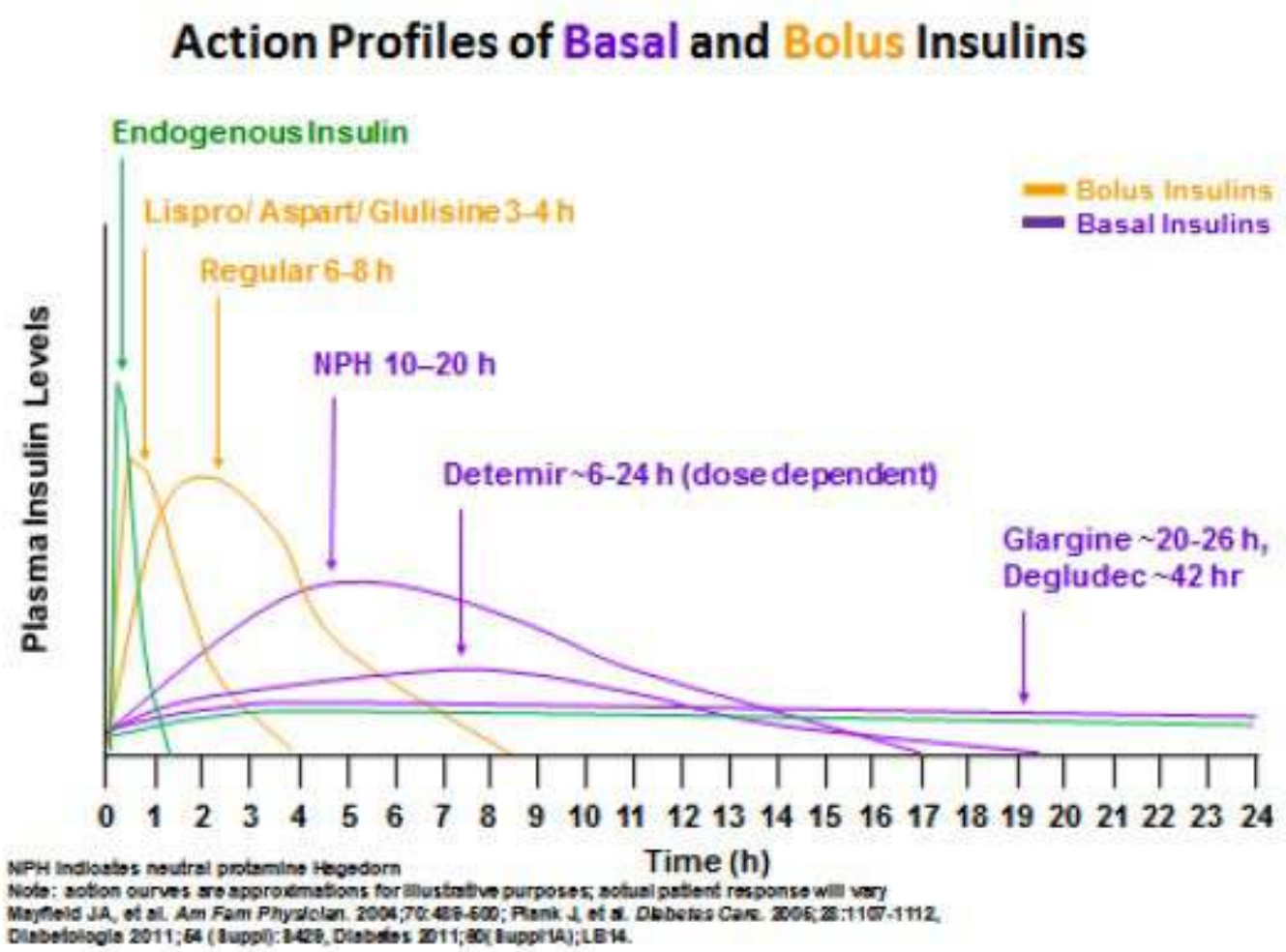
Glucagon > insulin

Glucose is released from storage

Keeping the Balance with Type 1 Diabetes



Insulin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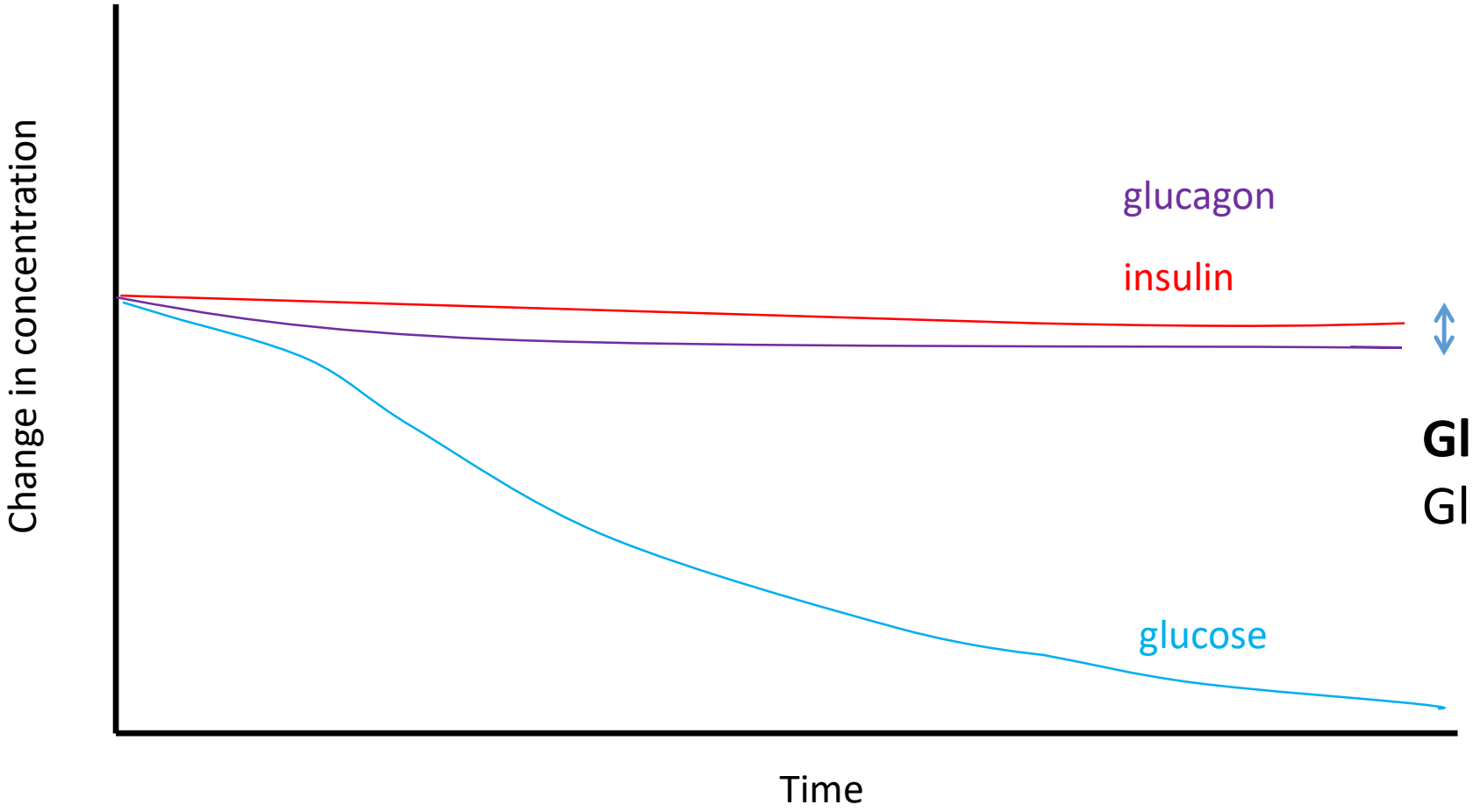
Aerobic Exercise in Type 1 Diabetes



Glucagon ~ insulin

Glucose is kept in storage

Bottom line….

- Ideally insulin should be adjusted BEFORE exercise
- Try to mimic what the pancreas would normally do
- Be aware of how much insulin could be in your system before exercise
  - Basal insulin?
  - Meal bolus?
  - Correction bolus?
- Try to avoid aerobic exercise when insulin could be at its peak
- Try to avoid injecting insulin into muscles that are about to be used

Exercise management in type 1 diabetes: a consensus statement

Michael C Riddell, Ian W Gallen, Carmel E Smart, Craig E Taplin, Peter Adolfsson, Alistair N Lumb, Aaron Kowalski, Remi Rabasa-Lhoret, Rory J McCrimmon, Carin Hume, Francesca Annan, Paul A Fournier, Claudia Graham, Bruce Bode, Pietro Galassetti, Timothy W Jones, Iñigo San Millán, Tim Heise, Anne L Peters, Andreas Petz, Lori M Laffel

Lancet Diabetes Endocrinol. 2017 May;5(5):377-390.

This is where all of the recommendations for insulin adjustments and carbohydrate intake in this presentation come from!

Adjusting Insulin Before Exercise: Insulin Pumps

- Basal rate reduction for aerobic exercise (ideal situation where exercise is planned in advance)
  - ➢Set temporary basal at least 90 minutes before exercise
  - ➢Reductions can vary from 50 to 100%
  - ➢Decrease nocturnal basal rate post-exercise

Pump Adjustments Should be Made Before Exercise

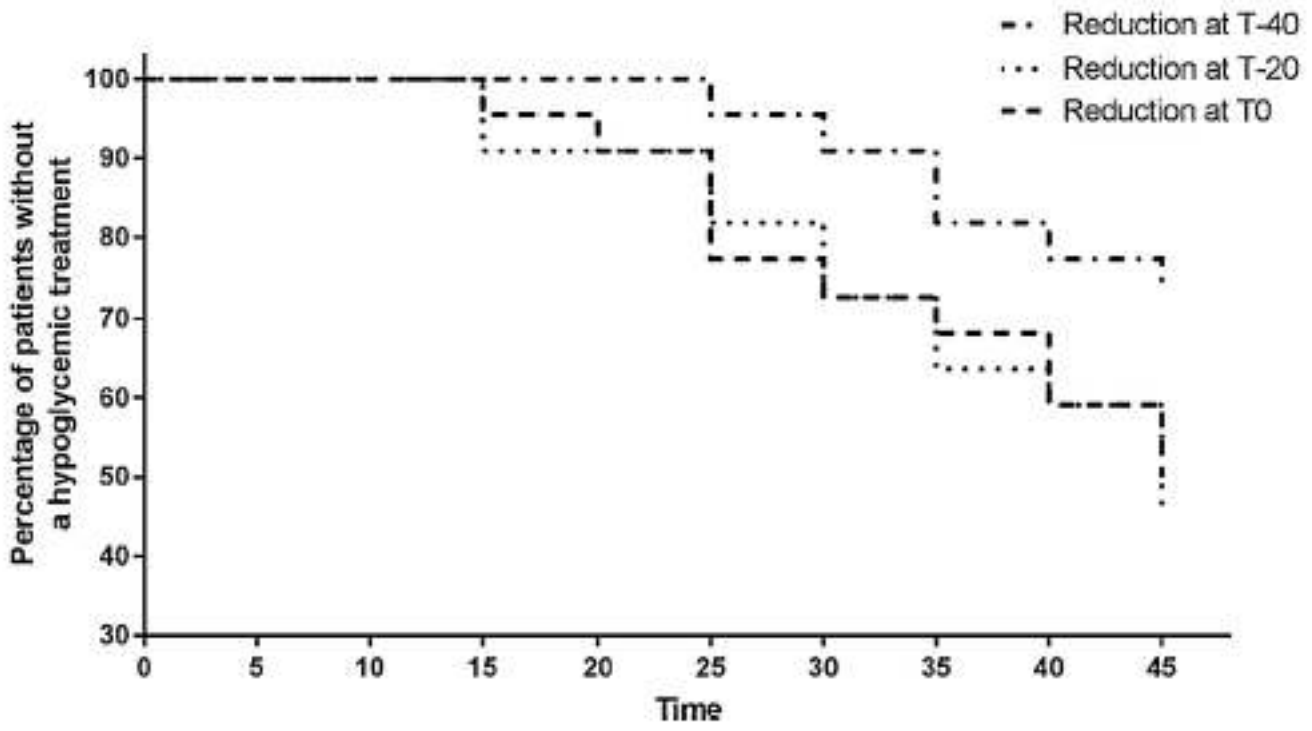


Fig. 3. Survival curve of hypoglycaemic treatments for the threeinsulin basal rate reduction strategies.

Roy-Fleming et al. Diabetes Metab. 2019;45(3):294

Adjusting Insulin Before Exercise: Insulin Pumps

- If temp basal not set early enough have a pre-exercise snack with a reduced bolus
- For exercise 30 minutes or less:
  - ➢25-50% reduction for snack 30 minutes before exercise
  - ➢50-75% reduction for snack 60 minutes before exercise

Adjusting Insulin Before Exercise: Multiple Daily Injections

- Basal insulin reductions for aerobic exercise
  - Reduce pre-exercise basal dose by 20%
  - Challenge: potentially planning for exercise the day before!
  - Consider decreasing post-exercise basal dose by 20%

Adjusting Insulin Before Exercise: Multiple Daily Injections

- Where reducing basal insulin is not practical, reduce bolus insulin with pre-exercise snack (exercise 30 minutes or less)
  - 25-50% for snack 30 minutes before exercise
  - 50-75% for snack 60 minutes before exercise

Carbohydrates For Longer Exercise…

- Aerobic exercise up to 60 minutes duration
  - May not be required depending on starting blood glucose, most recent insulin dose
- For exercise > 60 minutes, plan 30-60 g of CHO per hour
- For exercise > 150 minutes, 60-90 g of CHO per hour
- Increase carbohydrate supplementation if exercise occurs under high insulin conditions

INTENSITY

Different Intensity = Different Fuels

Aerobic (low to moderate intensity)

Type of Fuel	Storage Area
Fat	Adipose Tissue
Glucose	Blood Glucose
Amino acids	Muscle
Hormones	Insulin, glucagon

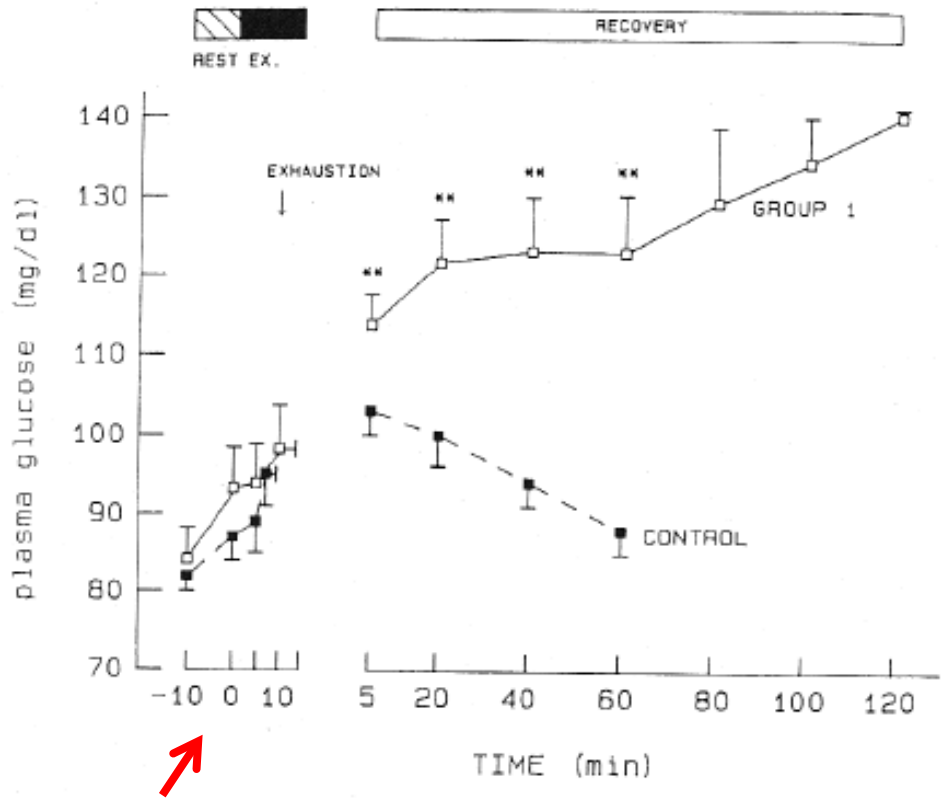
Anaerobic (high intensity)

Type of Fuel	Storage Area
Glucose	Muscle glycogen
Glucose	Liver Glycogen
Hormones	Epinephrine, norepinephrine

Fight or Flight Response

- Prepares body for action (sympathetic nervous system)
- Epinephrine and norepinephrine released
- Blood pressure, respiration, heart rate increase
- Blood flow to muscle enhanced
- Fuels (glucose and free fatty acids) released from storage into the blood
- Metabolic rate/fuel usage increases

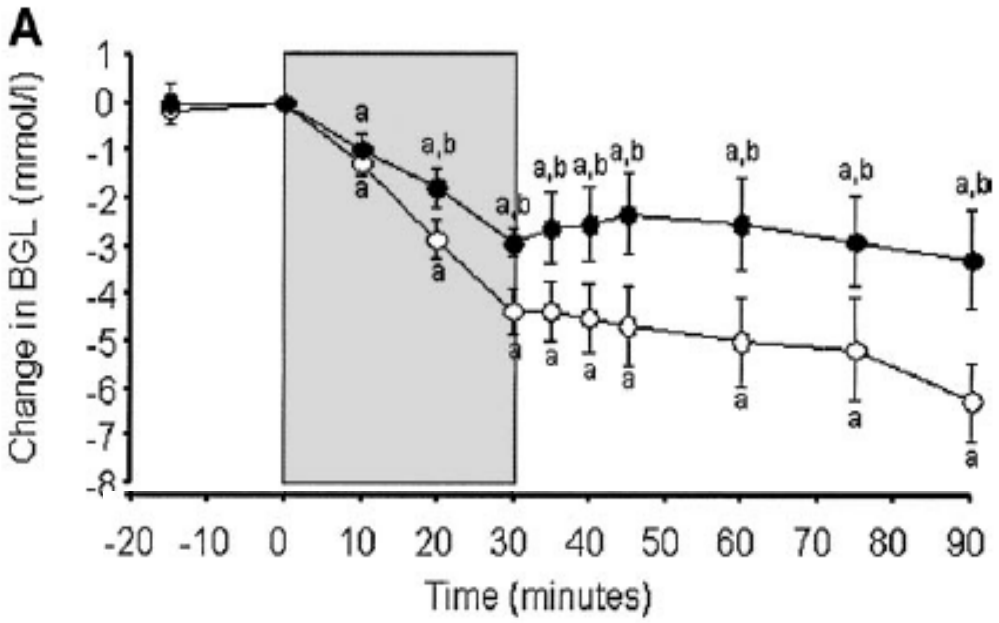
High Intensity Exercise and Hyperglycemia



Cycling at >80% of max to exhaustion

Mitchell et al (1988) Diabetes Care 11(4):311-17

High Intensity Intermittent Exercise



Guelfi et al (2005) Diabetes Care 28:1289-1294

Howlinhockey.com

Factors Affecting Fight or Flight Responses

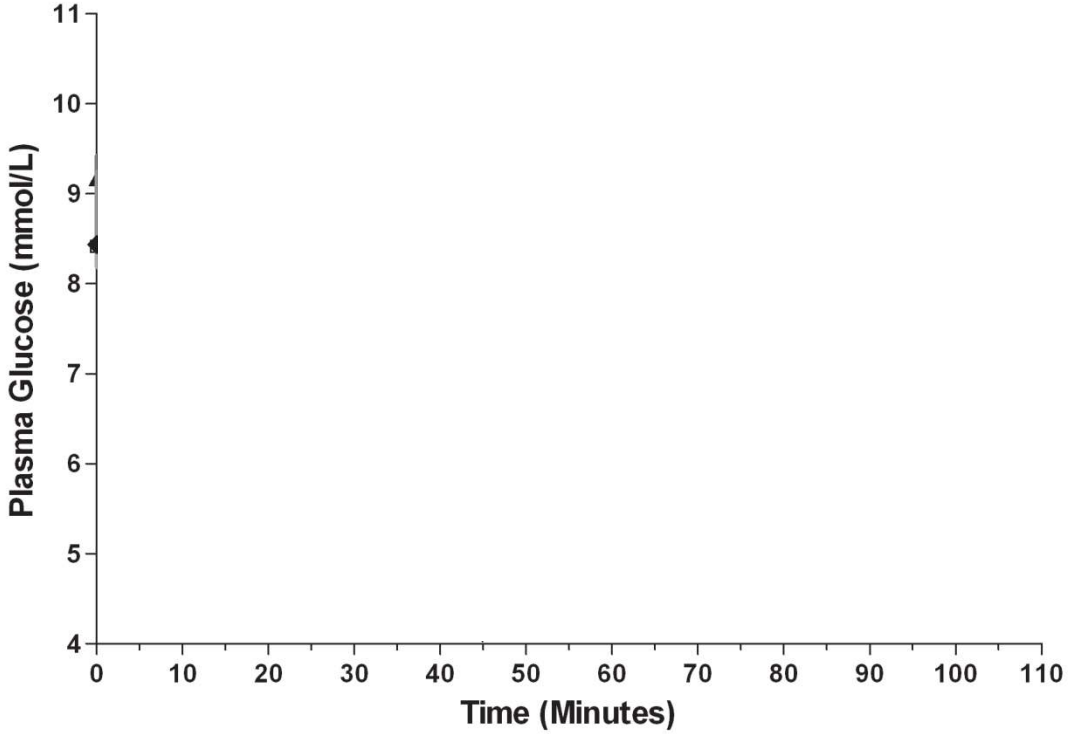
- Fear, anxiety, anticipation, anger, stress (e.g. competition!)
- Age (younger > older)
- Fitness (more fit > less fit)
- Sex (men > women)
- Some medications/medical conditions

Responses can be extremely variable

Definitions & Clarifications

- Resistance exercise (weight lifting) is generally considered to be “anaerobic” (i.e. high intensity) exercise
- Effects on the body depend on the number of repetitions, amount of weight lifted, rest between sets, etc.
- High repetition low resistance = more aerobic
- High resistance low repetition = more anaerobic

Aerobic vs. Resistance Exercise in T1D



a – significant change from baseline (aerobic)
b – significant change from baseline (resistance)
c – significant difference between aerobic & control
d – significant change throughout recovery (aerobic)

Yardley et al. Diabetes Care 2013; 36(3): 537-42

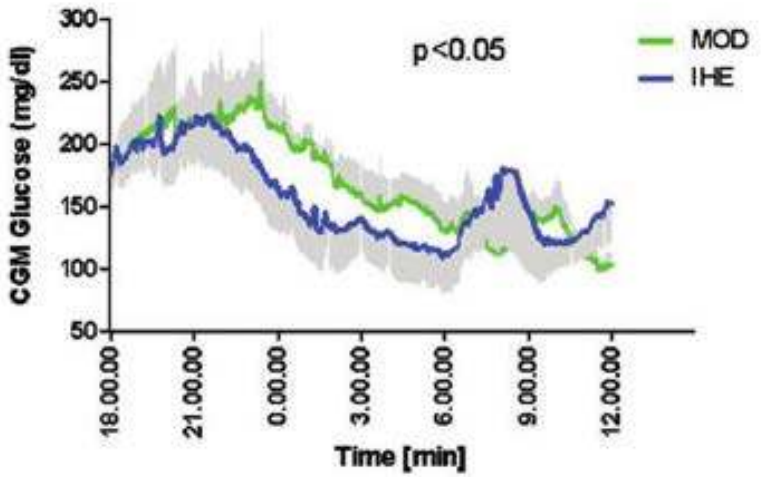
Keep in Mind

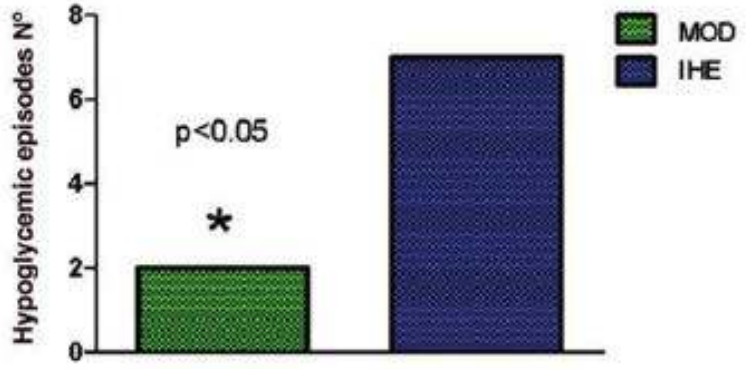
- You can only use what you have stored
  - Multiple training sessions or competitions in a day
  - Consecutive days of training or competition
  - Fasting
  - Very low carbohydrate diets
- Eventually you have to pay back what you use
  - Glucose stores in muscle and liver need to build back up

Insulin Adjustments for Anaerobic Activity are Smaller

- Insulin pumps
  - Insulin reduction (both basal rate and/or bolus) might not be necessary (depending on intensity/duration)
  - Post-exercise hyperglycemia can be treated with increased basal rate BUT…
  - Consider decreasing nocturnal basal rate by 20%
- Insulin injections
  - No pre-exercise basal injection reductions
  - Post-exercise basal injection reduction of 20%
  - Consider using bolus insulin to correct for post-exercise hyperglycemia

Potential Problems with High Intensity Exercise





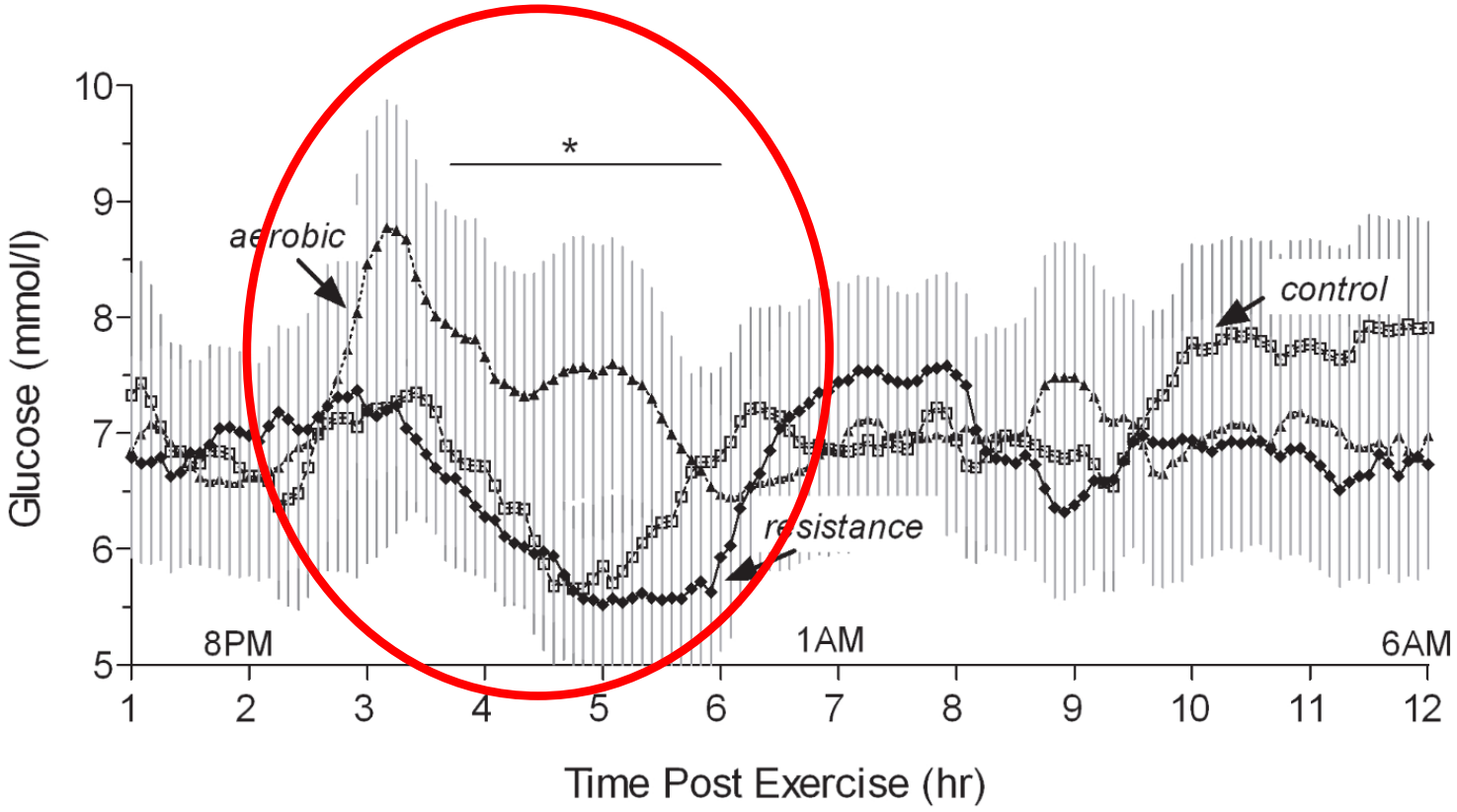
30 min moderate cycling (40%max)

30 min moderate cycling (40%max) with 5 second bursts (85% max) every 2 minutes

The risk of late onset hypoglycemia might be increased with high intensity exercise

Maran et al. (2010) Diabet Sci Technol Ther 12: 763

Potential Problems with High Intensity Exercise



Yardley et al. Diabetes Care 2013; 36(3): 537-42

Take-Home Messages

- Aerobic exercise
  - Usually makes blood glucose go down
  - Insulin adjustments at least 90 minutes pre-exercise will give best results
  - Keep some carbohydrates nearby
- Anaerobic exercise
  - May make blood glucose go up instead of down
  - Usually requires smaller insulin adjustments
  - Might not need any carbohydrates during exercise
  - Might need more carbohydrates several hours after exercise

What can you do to exercise safely?

- Keep a diary to track the following things:
  - Type, timing (including time of day), intensity, duration of exercise
  - Carbohydrate intake and insulin adjustments
- Be as consistent as possible and check your glucose often
- Use a CGM to determine blood glucose trends
- Experiment with one variable at a time
- Make small adjustments to find what works

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Questions?

jane.yardley@ualberta.ca

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