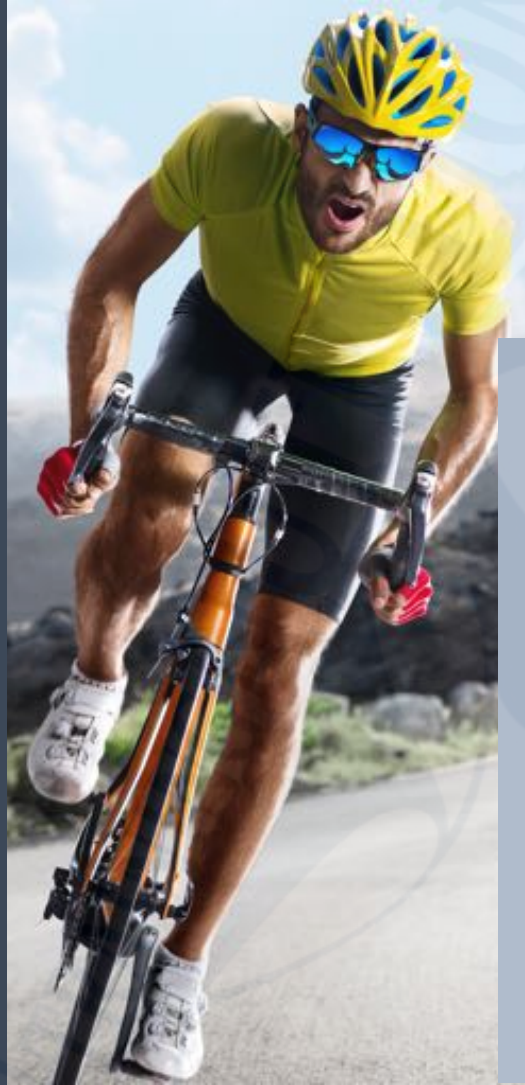




CARBOHYDRATES Fast fuel  
& optimal recovery

# DID YOU KNOW



Typical daily carbohydrate needs for a pro-cyclist doing the Tour de France vary from 500-700g/ day! That is the equivalent of 100 – 140 teaspoons of sugar!

Interestingly, approximately 2/3 of this is consumed after the race.

([www.otesports.co.uk](http://www.otesports.co.uk))



# OBJECTIVES

- What are carbohydrates (CHO)
- How are they digested
- Why are CHO important
- Calculating CHO requirements
- CHO timing
- Types of CHO
  - Carbo loading
  - Train low, compete high



# IMPORTANT NOTE

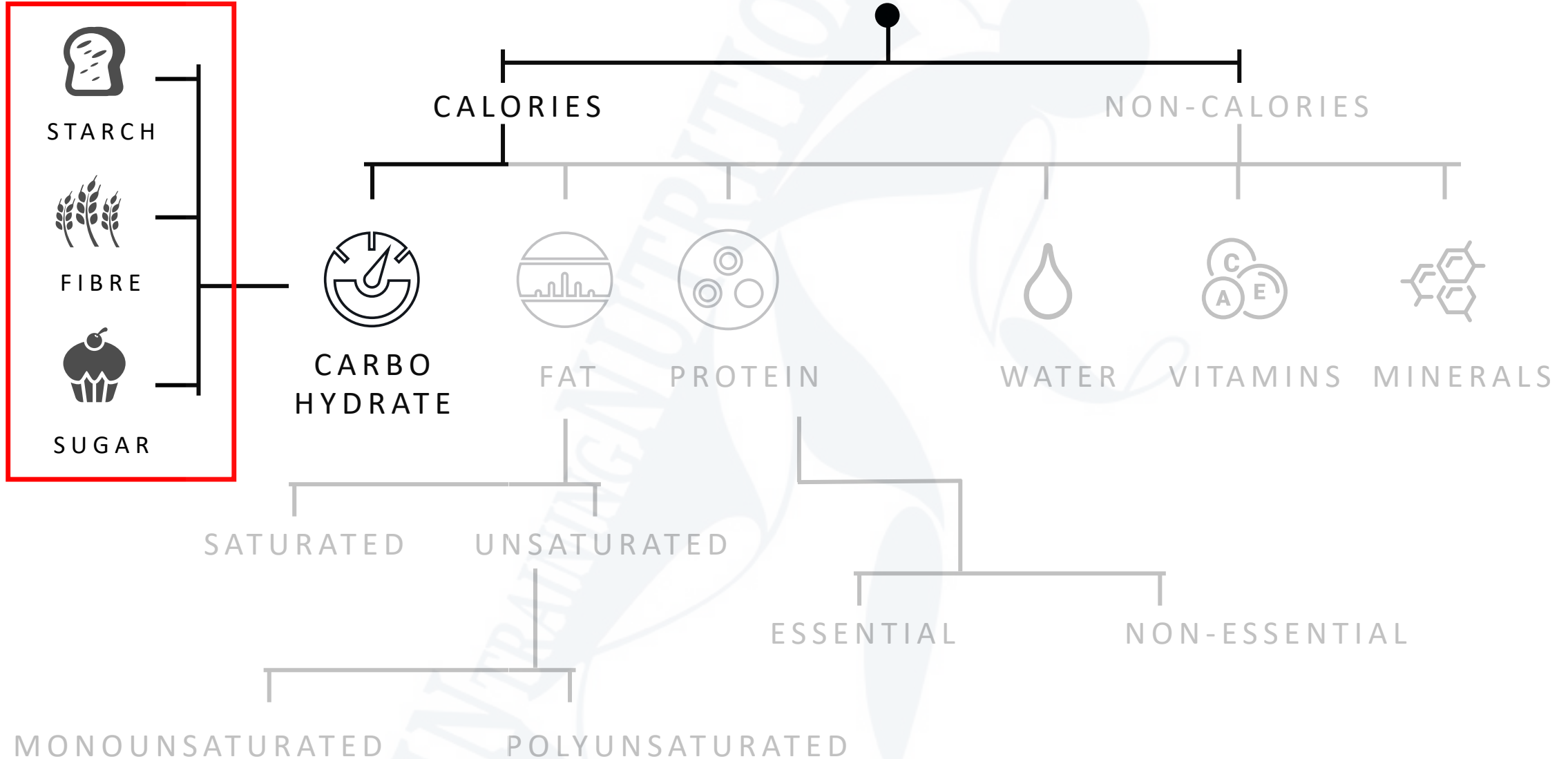
---

Specific  
recommendations  
are for athletes  
(i.e. trained  
individuals)

Guidelines may be  
useful for  
exercisers

Individualise/ fine  
tune to unique  
needs & training

# NUTRITION





# TYPES OF CHO FOODS



**STARCHES**



**FIBRE**



**SUGAR**

(Mahan & Raymond, 2017)



# STARCH

## RICH FOODS

---

### Starchy vegetables

- Peas, corn, potato & sweet potato



### Legumes

- Beans, lentils & chickpeas

### Grains

- Oats, barley, rice, wheat & others
  - Wholegrains
  - Refined grains



(American Diabetes Association, n.d.)



# MINIMALLY PROCESSED

---

“Does my starch look the same on the plate as it does on the plant?”

— Abby the Dietitian



(American Diabetes Association, n.d.)





# FIBRE

## & HEALTH

---

- Plant based foods
  - Undigested nutrient
- Need 25 – 30g/ day
  - Improve digestion
  - Lower blood sugar
  - Reduce risk of heart disease
- Two main types of fibre:
  - Soluble and insoluble

(American Diabetes Association, n.d.)





# FIBRE

## RICH FOODS

---

- Minimally processed:
  - Fruit & vegetables
  - Legumes
  - Grains
  - Wholegrain cereals & breads
- Dietitian's top tip:
  - Increase intake slowly

(American Diabetes Association, n.d.)



# INTRINSIC SUGAR

---

- Found in a food matrix
  - Other beneficial nutrients
- Fruit (fructose)
  - Vitamins & minerals
  - Fibre
- Milk/ dairy (lactose)
  - Protein & fats
  - Minerals (calcium, magnesium phosphates)



(American Diabetes Association, n.d.)

# ADDED SUGAR

---

- Added to foods/ drinks
  - When they are processed/ prepared
- Major sources include:
  - Soft drinks, energy drinks & sports drinks
- Goes by many names:
  - Table/ white sugar, brown sugar, syrup, honey, beet sugar, cane sugar, raw sugar, maple syrup, high fructose corn syrup, agave nectar



(American Diabetes Association, n.d.)





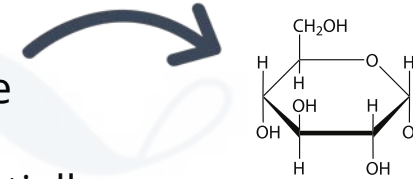
# SIMPLE vs COMPLEX

## CARBOHYDRATES

- Alternative terms for sugars & starches

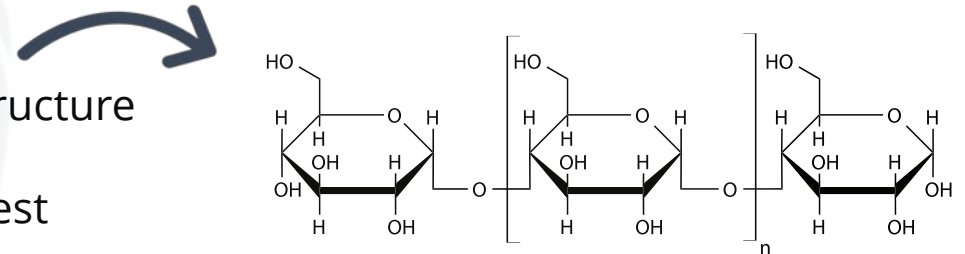
- Simple CHO:

- Shorter chemical structure
- Burned/ oxidised preferentially



- Complex CHO:

- Longer chemical structure
- Takes longer to digest
- Digestion slowed further by presence of fibre



(Mahan & Raymond, 2017)

# ENERGY IN CHO FOODS

4kCal/g



**STARCHES**

4kCal/g



**FIBRE**

4kCal/g



**SUGAR**

(Mahan & Raymond, 2017)



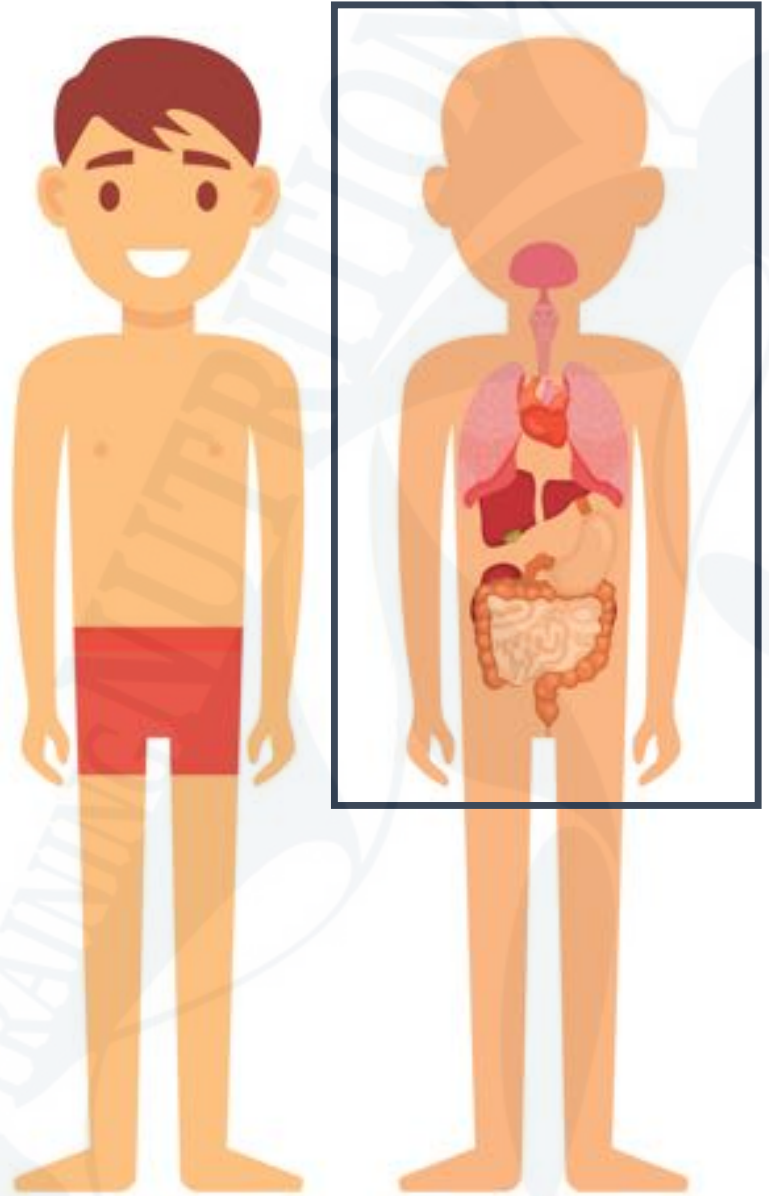
How are

- 
- 
- 
- 
- 
- 

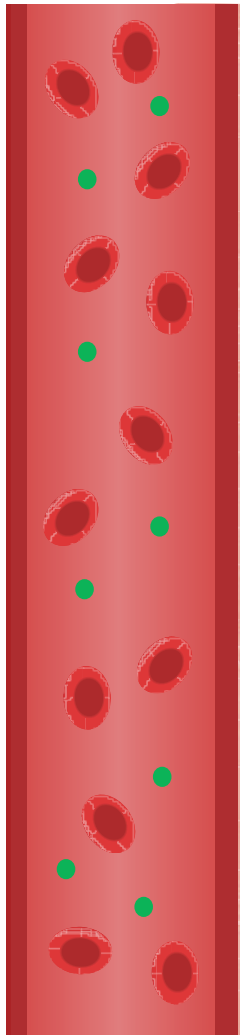
CHO digested?



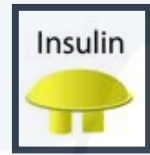
Meet  
**Tom...**







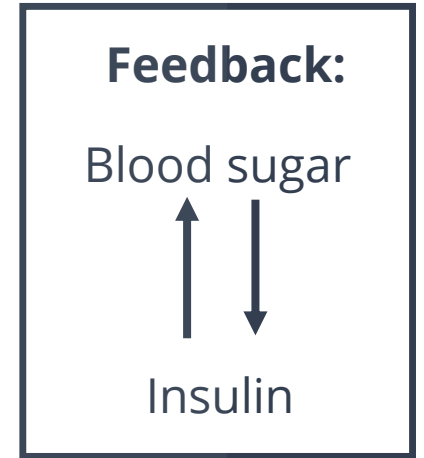
+ Pancreas

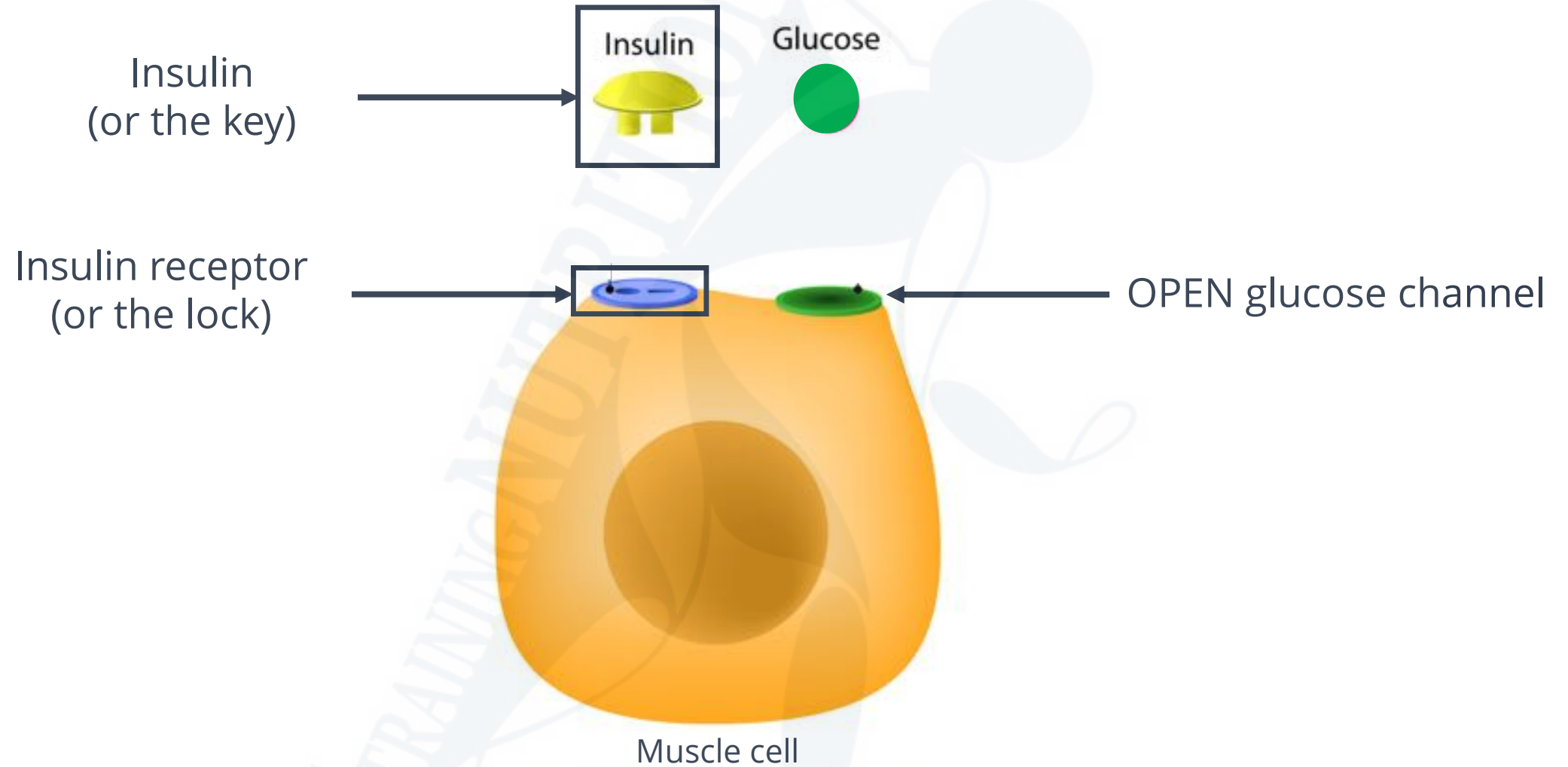


Glucose



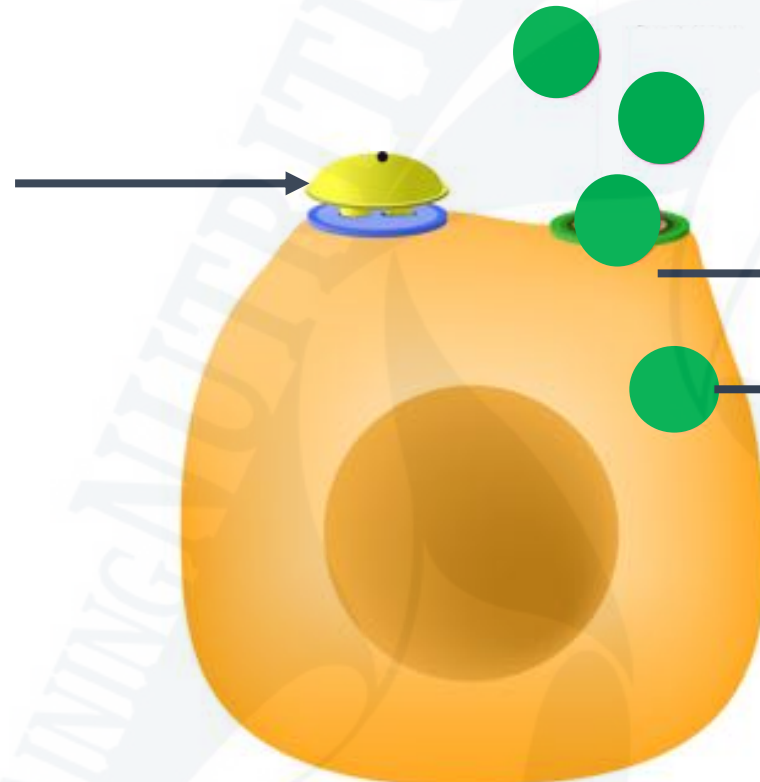
Muscle cell





(Mahan and Raymond, 2017)

Insulin connected to receptor (or the key is in the lock)



OPEN glucose channel

Glucose used by cell

Mitochondria

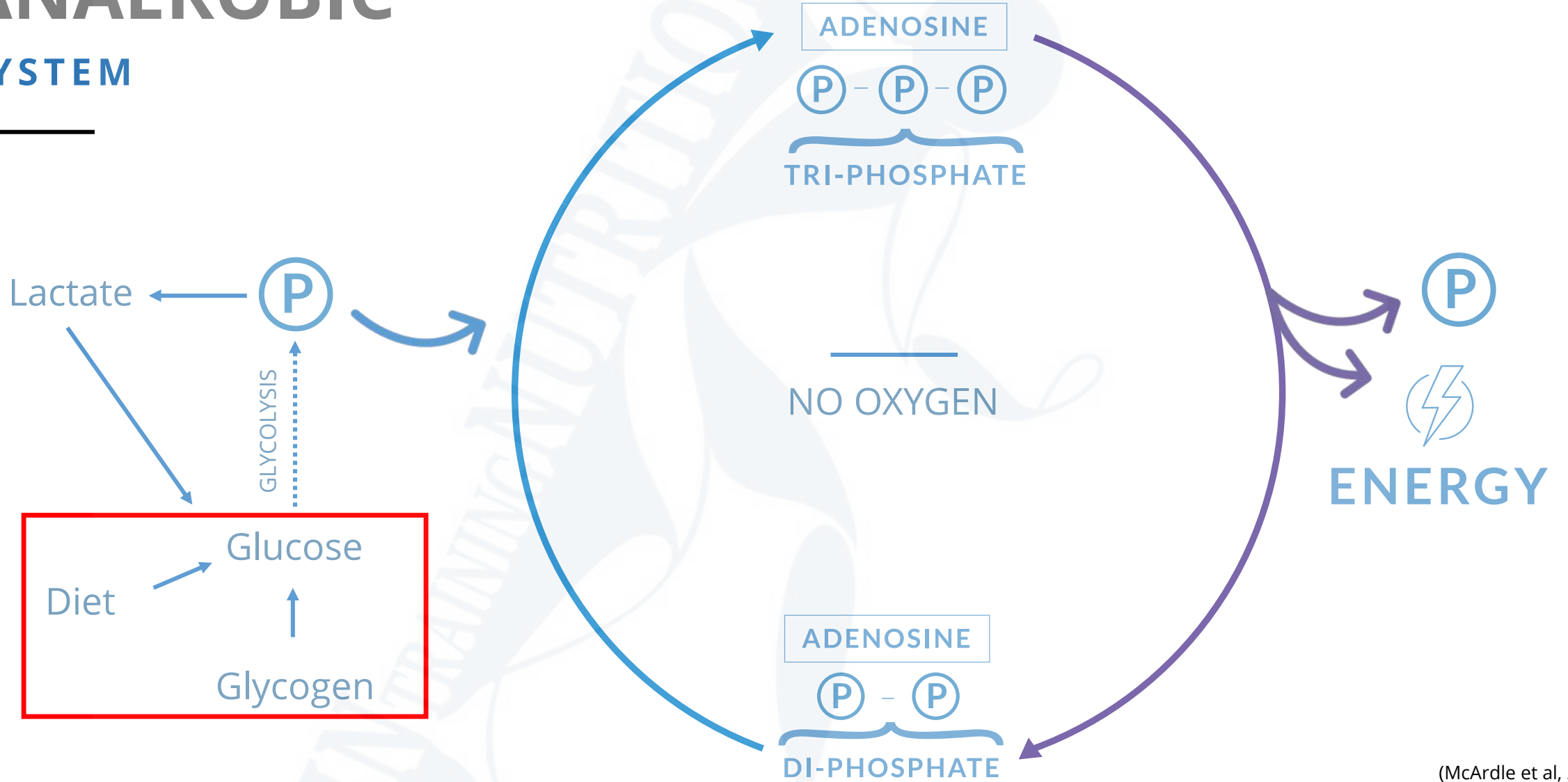
ENERGY!

Muscle cell

(Mahan and Raymond, 2017)

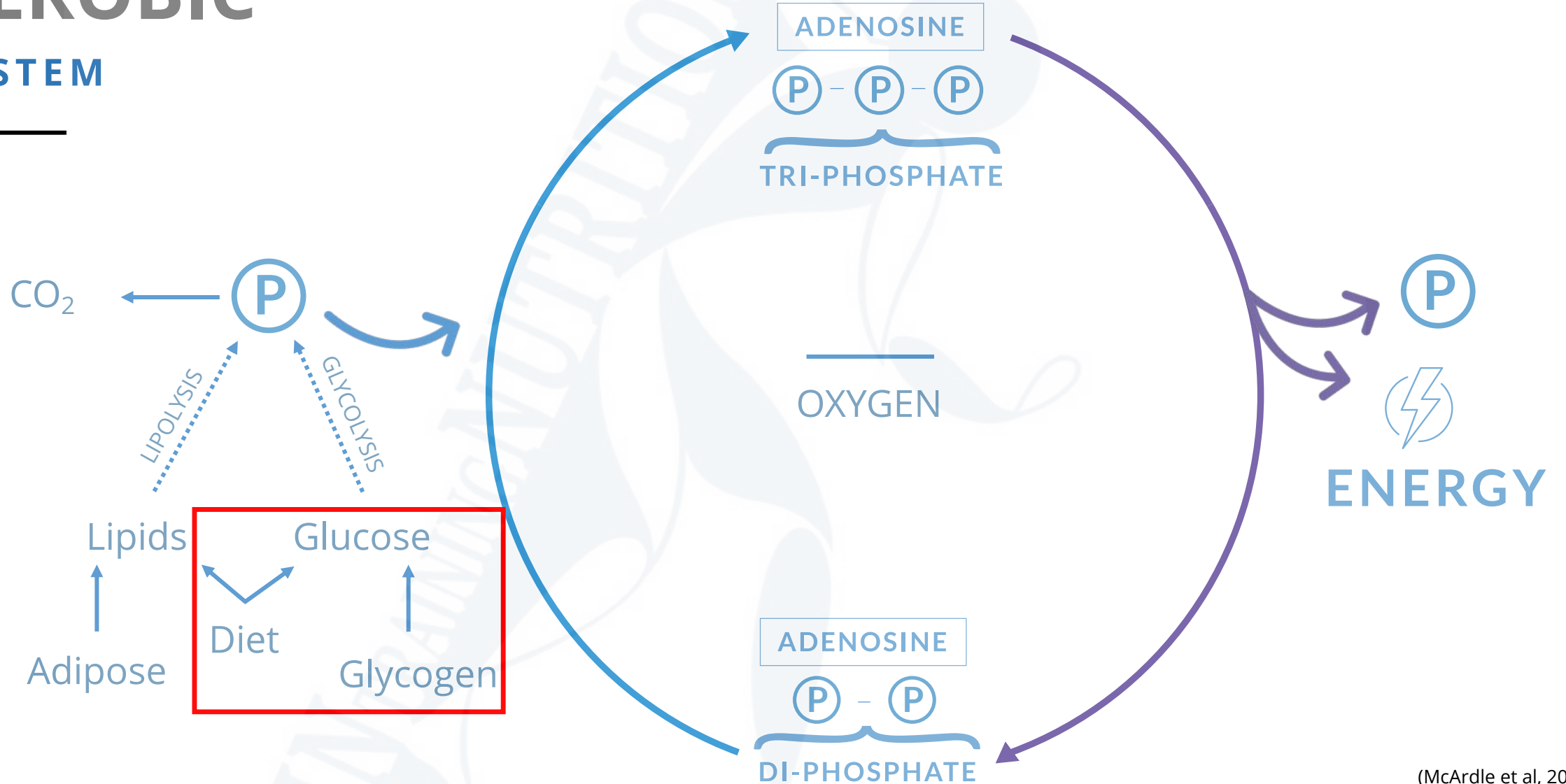


# ANAEROBIC SYSTEM



(McArdle et al, 2013)

# AEROBIC SYSTEM



(McArdle et al, 2013)

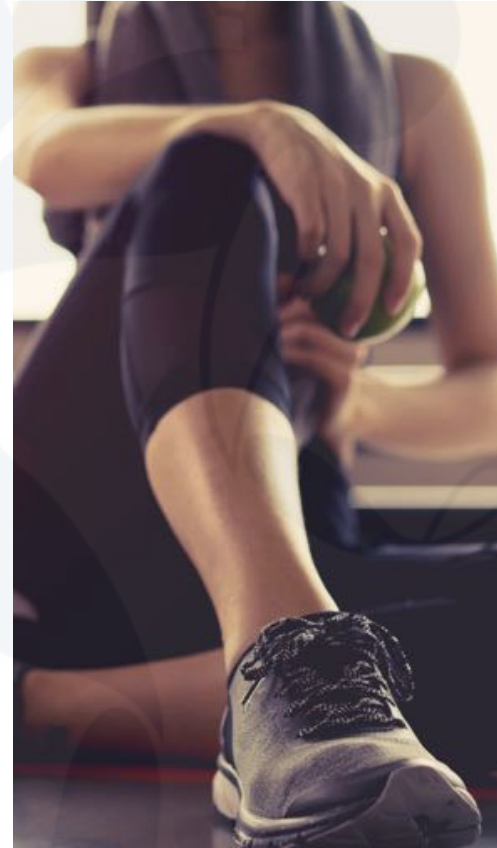
# WHY IS CHO IMPORTANT?



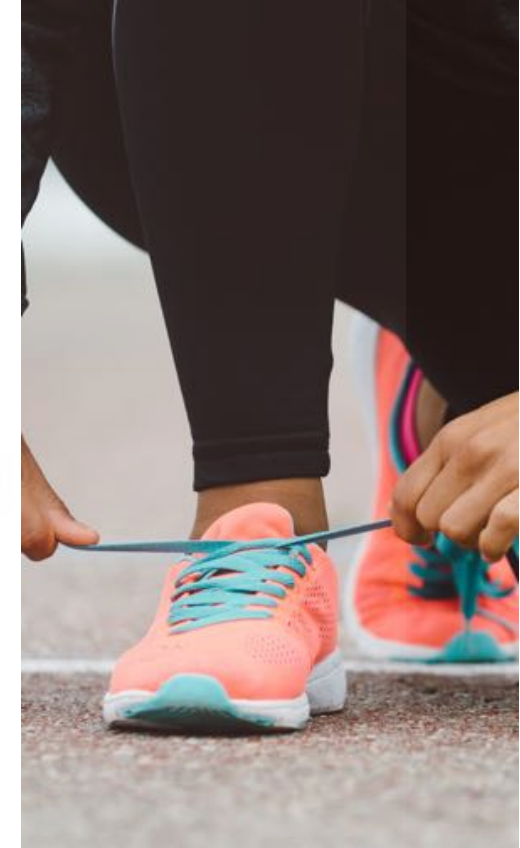
GLUCOSE =  
MAIN FUEL



ANAEROBIC &  
AEROBIC



EXOGENOUS &  
ENDOGENOUS



CURRENT &  
FUTURE  
PERFORMANCE

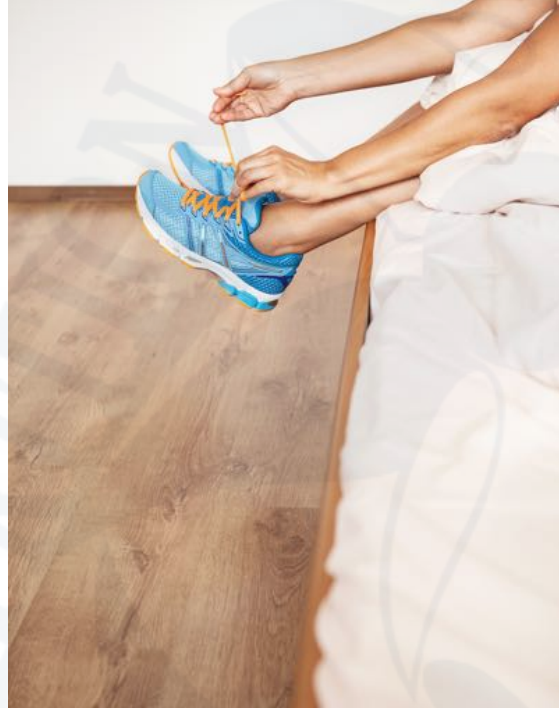
(Burke & Deakin, 2010)



# MUSCLE GLYCOGEN

---

- Storage of excess glucose for quick release
  - Direct relationship with CHO intake
- Increased stored:
  - Reduce fatigue & enhance performance
- Stores usually sufficient for < 90min
  - Thereafter, levels drop & intensity cannot be maintained
  - 'Hitting the wall'



(Burke & Deakin, 2010; Mahan & Raymond, 2017)

# MUSCLE GLYCOGEN

---

- Gradual depletion can occur:
  - High intensity training (repeated days)
  - High intensity training (multiple times/ day)
- **BOTTOM LINE:**
  - Train longer = better results
  - High muscle glycogen = train longer



(Mahan & Raymond, 2017)



# CHO REQUIREMENTS



**PROVIDE ENERGY**



**REPLENISH GLYCOGEN**



**PROTEIN SPARING**

- Depends on total daily energy expenditure, type of sport, gender & environmental conditions
  - % of total calories (for exercisers)
    - g/ kg for athletes

(Mahan & Raymond, 2017)

# CHO intake

For EXERCISERS



- Timed according to training
  - Optimal pre-workout nutrition
  - Encourage post-workout recovery
- **BOTTOM LINE:**
  - Most exercisers don't need to eat a substantially different diet to perform optimally
  - **45 - 55% of total energy**
  - **3 - 5g/kg/d**

(Mahan & Raymond, 2017)





# EXAMPLE

## EXERCISER

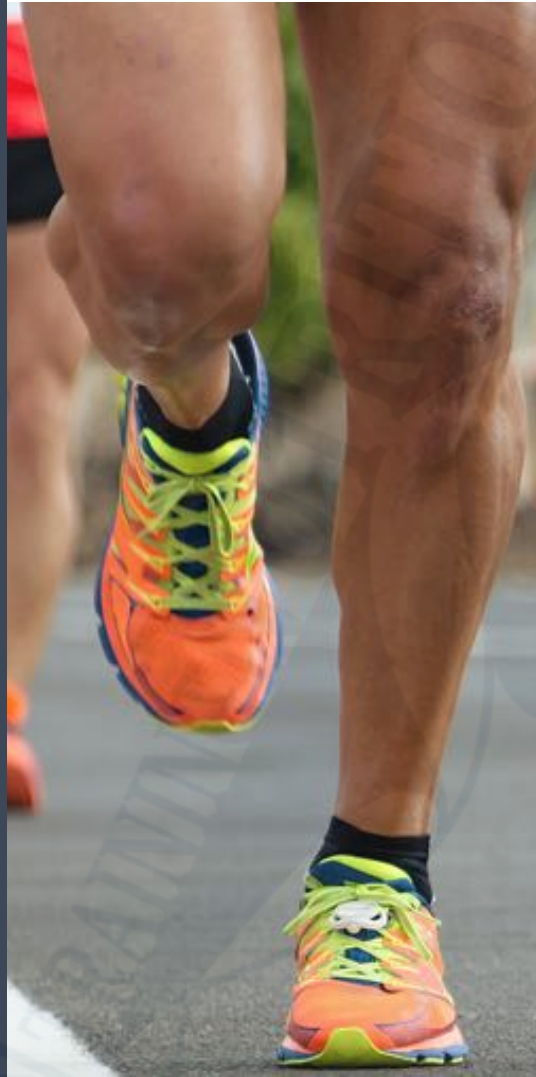
---

- **Weight:** 65kg (BMI: 21.7kg.m<sup>2</sup>)
- **Total energy:** 25 – 35kCal/kg
- **CHO:** 3 – 5g/kg/d
  
- **Energy:** 25 - 35 x 65 = 1625 - 2275kCal/ d
- **CHO:** 3 – 5 x 65 = 195– 325g/d

# CHO intake

For ATHLETES

International Olympics  
Committee (IOC)



Low intensity/ skill based

- 3 – 5g/kg/d

Moderate exercise (1 hour/ d)

- 5 – 7g/kg/d

Endurance (moderate-high), 1-3 hours/ d

- 6 – 10g/kg/d

Strength-training

- 4 – 7g/kg/d

Extreme (moderate-high) >4-5 hours/ d

- 8 – 12g/kg/d

(Potgieter, 2013)



# EXAMPLE

## ATHLETE (strength)

---

- **Weight:** 65kg (BMI: 21.7kg.m<sup>2</sup>)
- **Total energy:** 50 – 80kCal/kg
- **CHO:** 4 – 7g/kg/d
  
- **Energy:** 50 - 80 x 65 = 3250 - 5200kCal/d
- **CHO:** 4 – 7 x 65 = 260– 455g/d

\*At the end of L5 will calculate this in food terms





# CHO

## TIMING

---

- Ergogenic aid when used appropriately
- CHO pre-workout
  - Prevents hunger
  - Maintains optimal blood glucose levels
  - Is glycogen sparing
- Pre-workout meal can
  - Improve performance when compared to a fasted state

(Mahan & Raymond, 2017)

# PRE- EVENT/ WORKOUT MEAL



**1 - 4g/ kg CHO**

Specific: for athletes

Less for exercisers



**CHO based**

Fat delays gastric emptying

Full stomach = indigestion,  
nausea & vomiting



**1- 4 hours before**

Partial digestion & absorption

Time to top up blood glucose &  
muscle glycogen if needed

(Mahan & Raymond 2017; Driskell & Wolinsky, 2011, Potgieter, 2013)



# PRE-TRAINING

## FASTING

---

- Acceptable for exercisers
  - Not ideal for athletes
- May cause blood sugar & muscle glycogen levels to drop
  - Body will tap into liver glycogen
  - May affect physical & cognitive performance
- Metabolic advantages suggested
  - May increase fat oxidation (fat burning)



(Mahan & Raymond, 2017)





# CHO

## DURING A WORKOUT

---

- Endurance exercise > 60 minutes
  - Ensure sufficient energy in latter stages
  - Does not prevent fatigue but does delay it
    - Exogenous glucose used first
    - Spares endogenous glycogen
- Improves performance
- Enhances feelings of pleasure

(Driskell & Wolinsky, 2011; McArdle et al, 2013)

# CHO during

For ATHLETES

International Olympics  
Committee (IOC)



Brief exercise < 45 min

- Not needed

Sustained high intensity 45 – 75 min

- Small amounts including mouth rinse

Endurance & start-stop sports, 1 – 2.5 hours

- 30 – 60g/ hour

Ultra-endurance, >2.5 – 3 hours

- Up to 90g/ hour

(Mahan & Raymond, 2017; AID, 2014; Potgieter, 2013)



# CHO

## AFTER EXERCISE

---

Replenish glycogen stores

- Should be consumed within 30 min after exercise

Enable faster return to training

- Significant performance benefits
- Supports repetitive training
- Maintains long term health

5% glycogen restored each hour after exercise

- 20 hours to replace stores



(Mahan & Raymond, 2017; Potgieter, 2013)



# CHO after

For ATHLETES

International Olympics  
Committee (IOC)



## Speedy refuelling (< 8 hours between sessions)

- 1 – 1.5g/kg/hour directly after exercise
- Every 2 hours for the next 4– 6 hours

## Regular training/ longer recovery (1-2 days)

- To meet CHO goal for the day

## Adding 5 – 9g protein (per 100g CHO)

- May further increase glycogen resynthesis rates
- Provide amino acids for repair
- Promote an anabolic (building up) hormonal profile

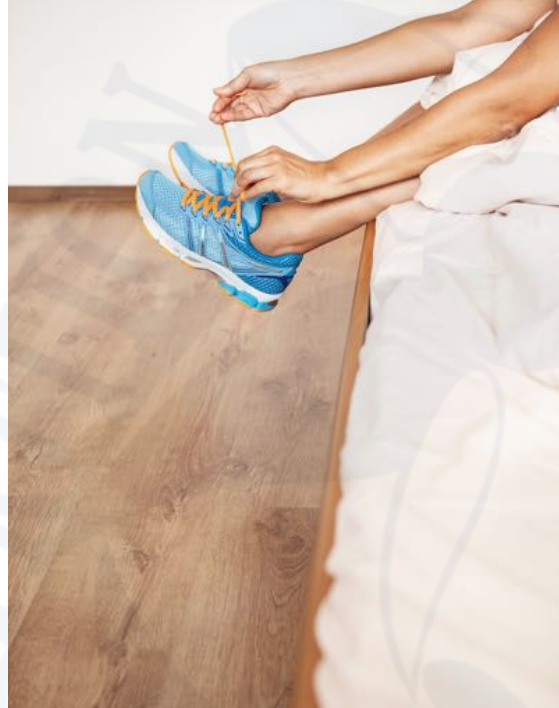
(Mahan & Raymond, 2017; Sousa et al, 2014; Potgieter, 2013)

# POST WORKOUT

## MEAL CHALLENGES

---

- Body core temperature is increased
  - Appetite is decreased
- May be easier/ simpler to drink
- **PROS:**
  - Often fortified with micronutrients
  - Ideal for athletes on the run
- **CONS:**
  - May contain banned substances
  - Not to replace whole foods often



(Mahan & Raymond, 2017)







# GLYCAEMIC INDEX

## FOR ATHLETES?

---

### Controversy

- No clear recommendations for athletes
- Improved metabolism & substrate utilisation with low GI foods
  - Does not translate into improved performance
- When CHO consumed during exercise
  - Diminishes GI effect of pre-event meal
- Low GI may be useful if limited intake of CHO during event is possible
  - Slower release may fuel exercise for longer



(Potgieter, 2013)

# CARBO

## LOADING

---

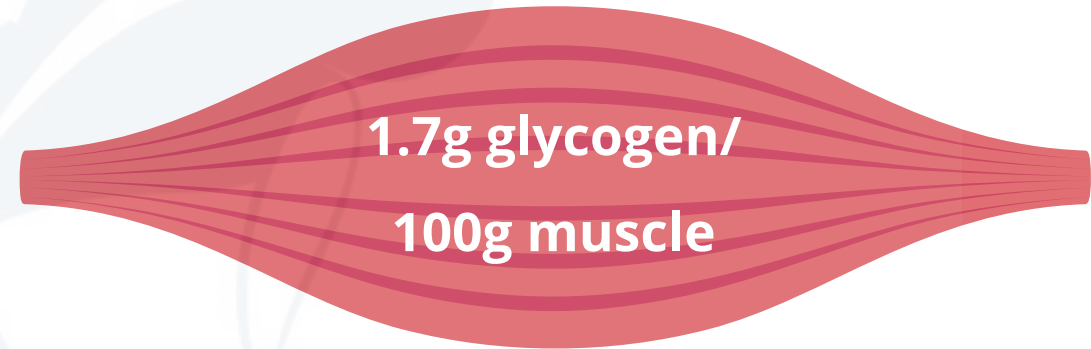
Glycogen supercompensation approach:

- 7 day CHO loading
- Muscle specific depletion training and low carb diet for 4 days
  - No training
  - High carb diet for 3 days

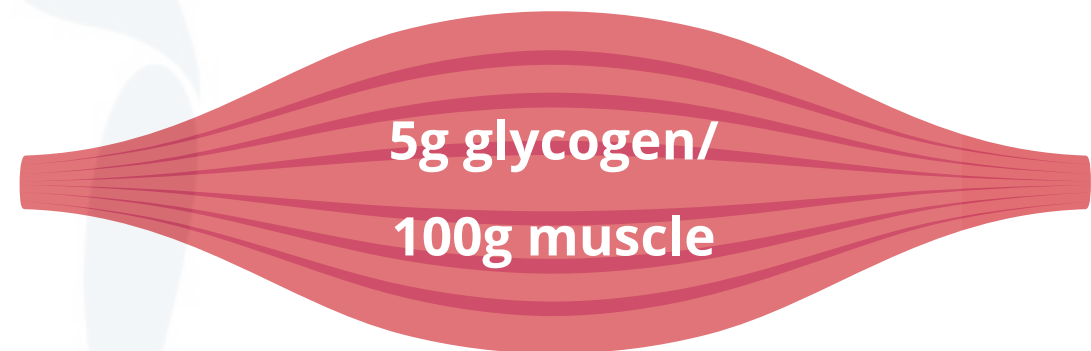
1g glycogen holds 2.7g water

- Is a 'heavy' fuel
- May hinder performance

Normal muscle:



Supercompensation muscle:



(McArdle et al, 2013)



# CARBO

## LOADING

---

- Benefit for endurance > 60 minutes
  - No benefit for higher intensity, shorter duration activity
- A modified approach may negate some of the negative outcomes
  - Gradual exercise tapering
  - Modified increase in carbs



(McArdle et al, 2013)



# TRAIN LOW

## COMPETE HIGH

---

- High fat, low CHO diet for up to 2 weeks
  - Normal training
- Followed by high CHO diet
  - Tapered training
  - (1-3 days pre-competition)
    - May increase the rate of fat oxidation/ fat 'burning'
- May slow the breakdown of glycogen during submaximal exercise
  - i.e. body will burn fat for submaximal and retain glycogen for high intensity



(Burke & Deakin, 2010, Potgieter, 2013)



# NEXT LESSON

## FATS

Functions, structure & types of fat

Storage of fat

Dietary fat recommendations

High fat diets & exercise

- Timing of fat intake & exercise
- Fat stores as fuel for exercise
- Increasing fat burning

Ranges for normal body fat %



# SUMMARY

- CHO is found in a variety of foods:
  - Starches, fibre & sugars
- Insulin assists with CHO digestion, absorption & utilisation
- Muscles obtain glucose from various sources
- Optimal CHO intake provides:
  - Energy & replenishes glycogen stores
- More glycogen in muscles
  - Delay fatigue & increase performance





# SUMMARY

- CHO requirements should be sufficient
- CHO requirements in exercisers (%) and athletes (g/kg) differ
- CHO is recommended:
  - Before, during (if >60 minutes) and after exercise
- The choice of CHO should aim to enhance health
  - Not huge performance differences
- Modified CHO loading may be beneficial
- Train low, compete high may benefit select ultra endurance athletes