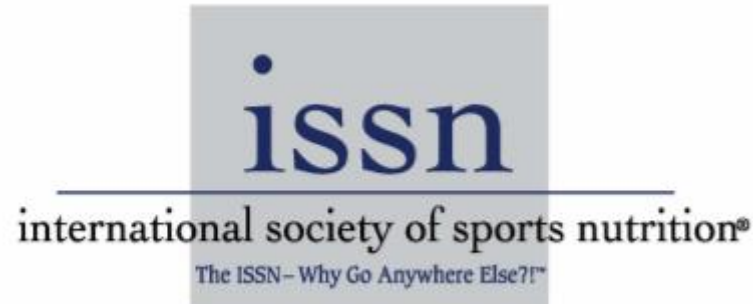


# Astaxanthin: Performance, Recovery, and Endurance

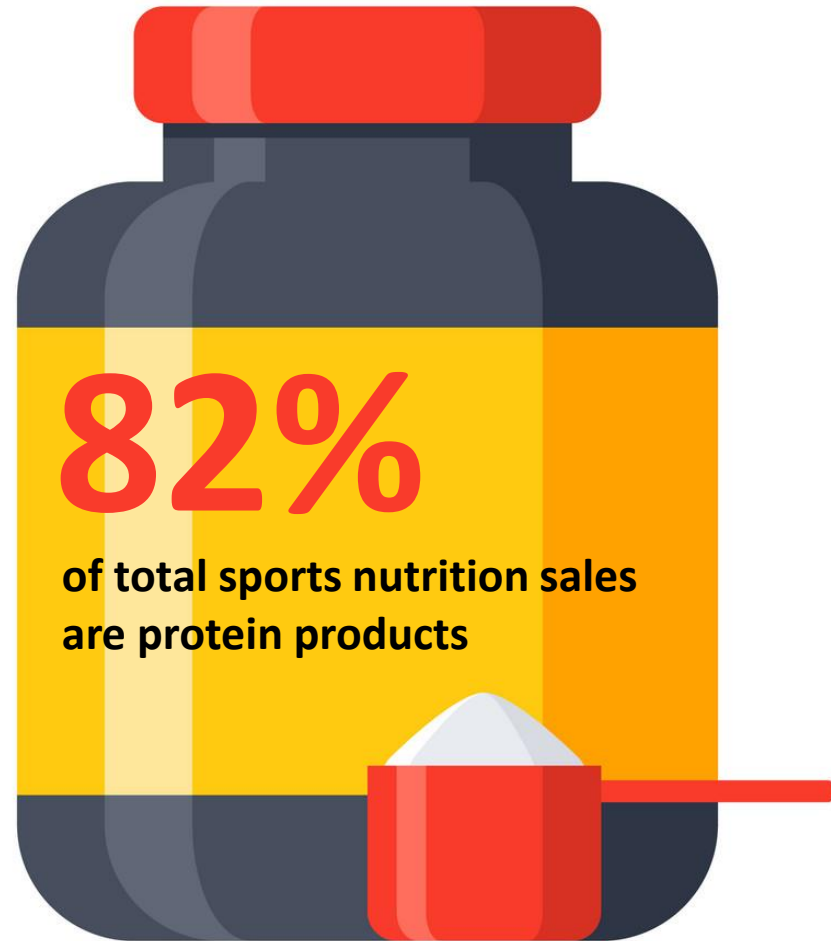
The 16th Annual ISSN Conference and Expo  
June 15<sup>th</sup>, 2019



30 YEARS  
of RESEARCH &  
INNOVATION



# Protein Dominates, But What Else is New?



Euromonitor International



**1 in 3**

new launches in 2018 contained  
phytonutrients or plant based nutrients.

**17%**

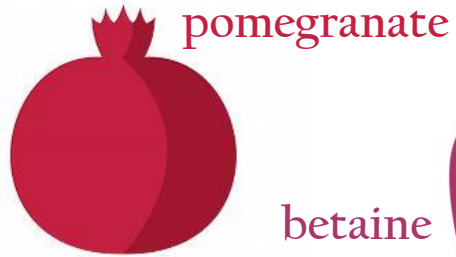


global increase in use of vegetarian protein

Innova Market Insights

# Phytonutrients for Sports Nutrition

## Popular Plant Based Nutrients:



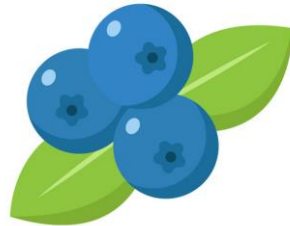
betaine



tart cheery



flavonoids



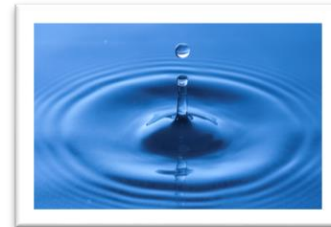
quercetin



carotenoids



Building blocks



Hydration



Inflammation



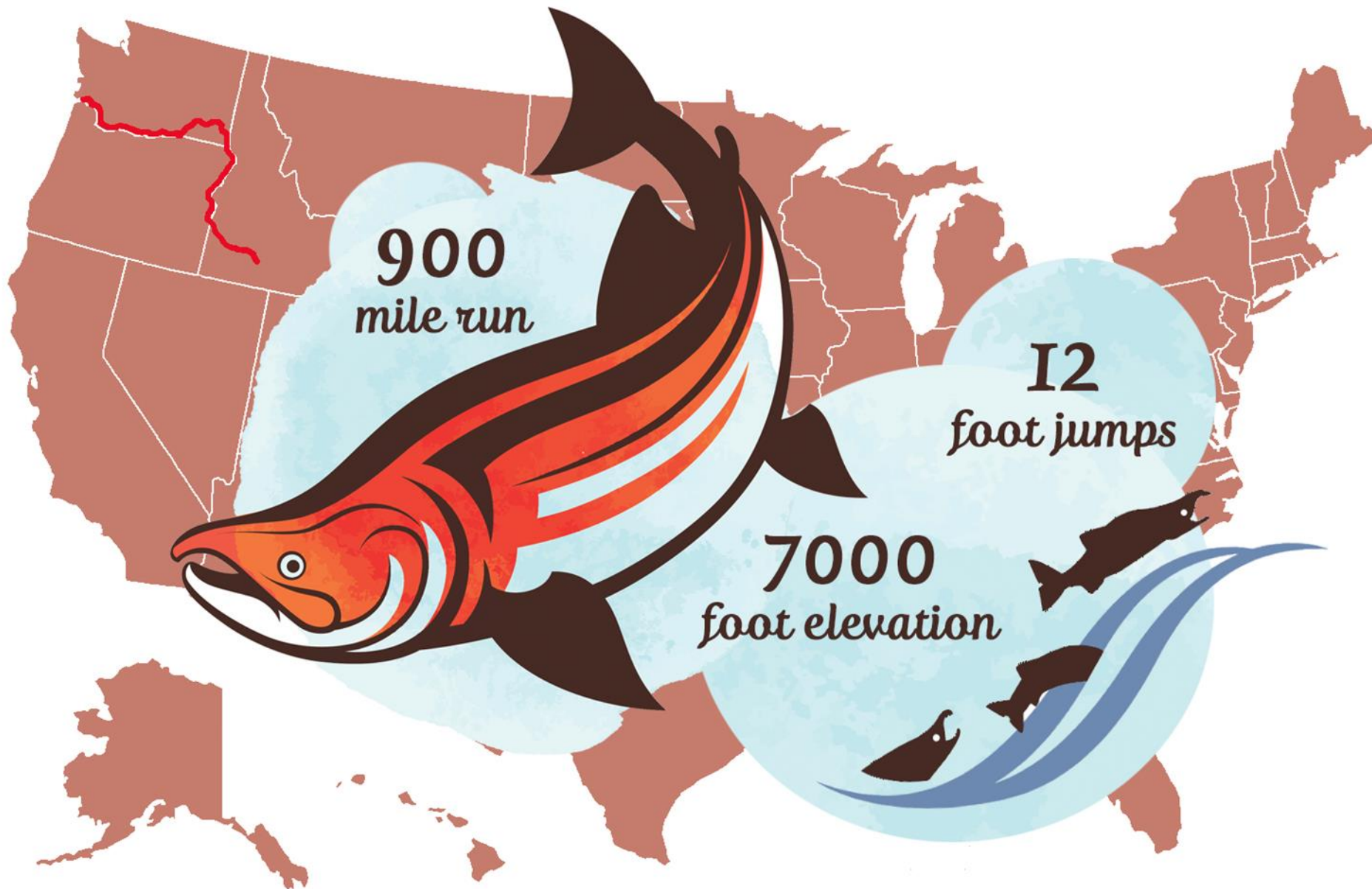
Oxidative Stress



Energy



# Phytonutrients in Nature: Salmon Run on Astaxanthin

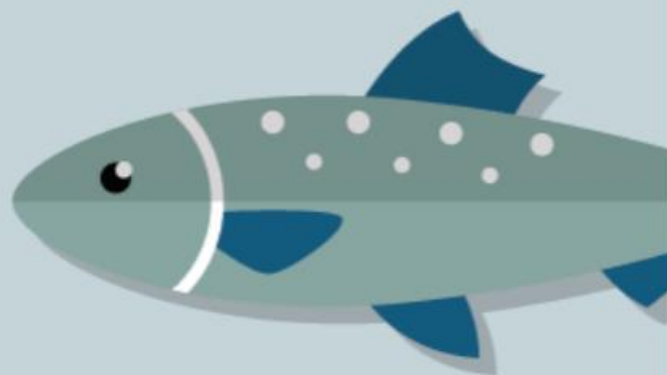


***Natural astaxanthin  
is an essential  
nutrient for salmon***



# Natural Astaxanthin in Our Diet

Natural astaxanthin is a nutrient that can be found in some seafoods, like salmon.



Clinical studies show that 4-6 mg/day supports muscle function. However, it's hard to get enough natural astaxanthin from diet alone.



## WOULD YOU EAT THIS MUCH RAW WILD SALMON DAILY?

Fillet based on 3.5oz or 100g serving. Salmon Astaxanthin content based on European Food Safety Authority.



ASTAREAL®  
6mg Softgel



SOCKEYE  
1.6 Servings



COHO  
2.9 Servings

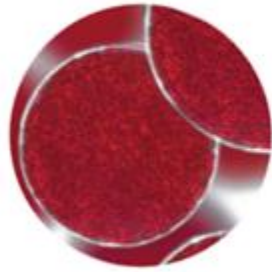


KING  
12 Servings



# Natural Astaxanthin Comes from Algae

algae



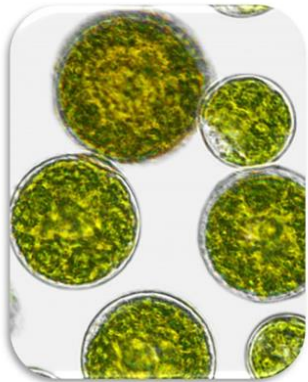
krill



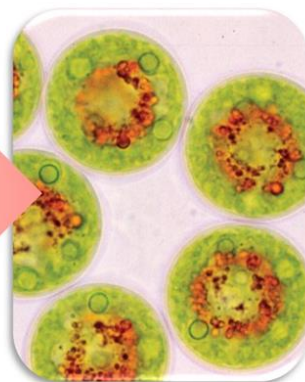
salmon



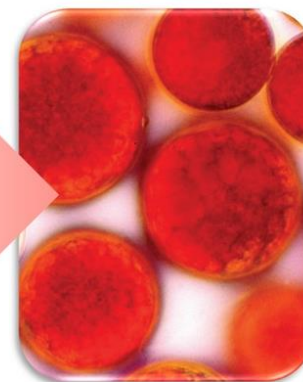
*Haematococcus pluvialis*



GREEN PHASE



INTERMEDIATE



RED PHASE





# Specific Consumer Needs by Age/Gender/Lifestyle

Pre-Workout



Intra-Workout



Post-Workout



Endurance/Sustained Energy

Recovery/Beating DOMS

Strength & Beauty



Healthy Aging



# AstaReal® Astaxanthin: The Most Studied Brand

More than 150 published studies

More than 60 published clinical studies

with AstaReal® Astaxanthin





# Why is Astaxanthin an Important Nutrient?

## Strongest Superoxide Scavenger

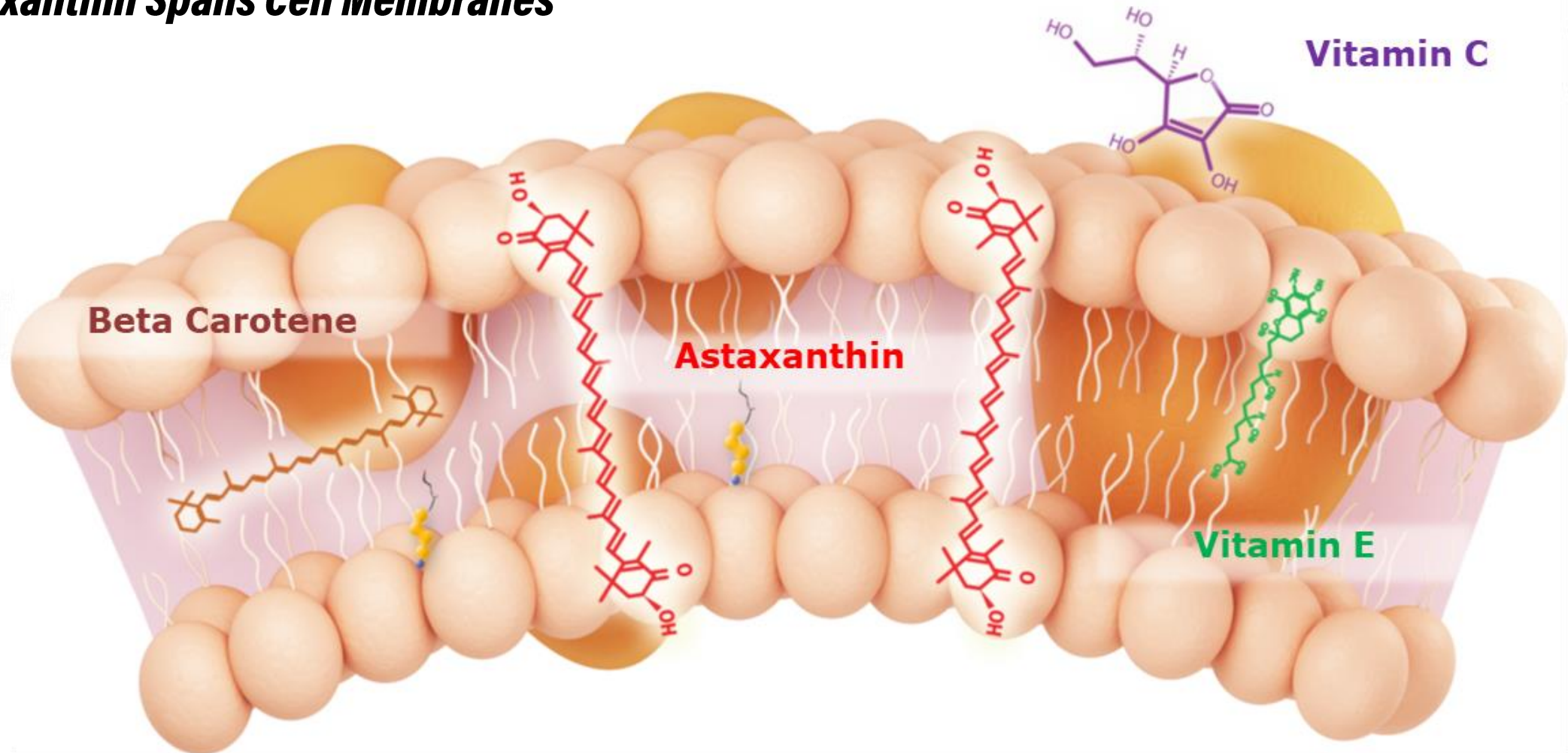


Copyright 2017 AstaReal Inc.

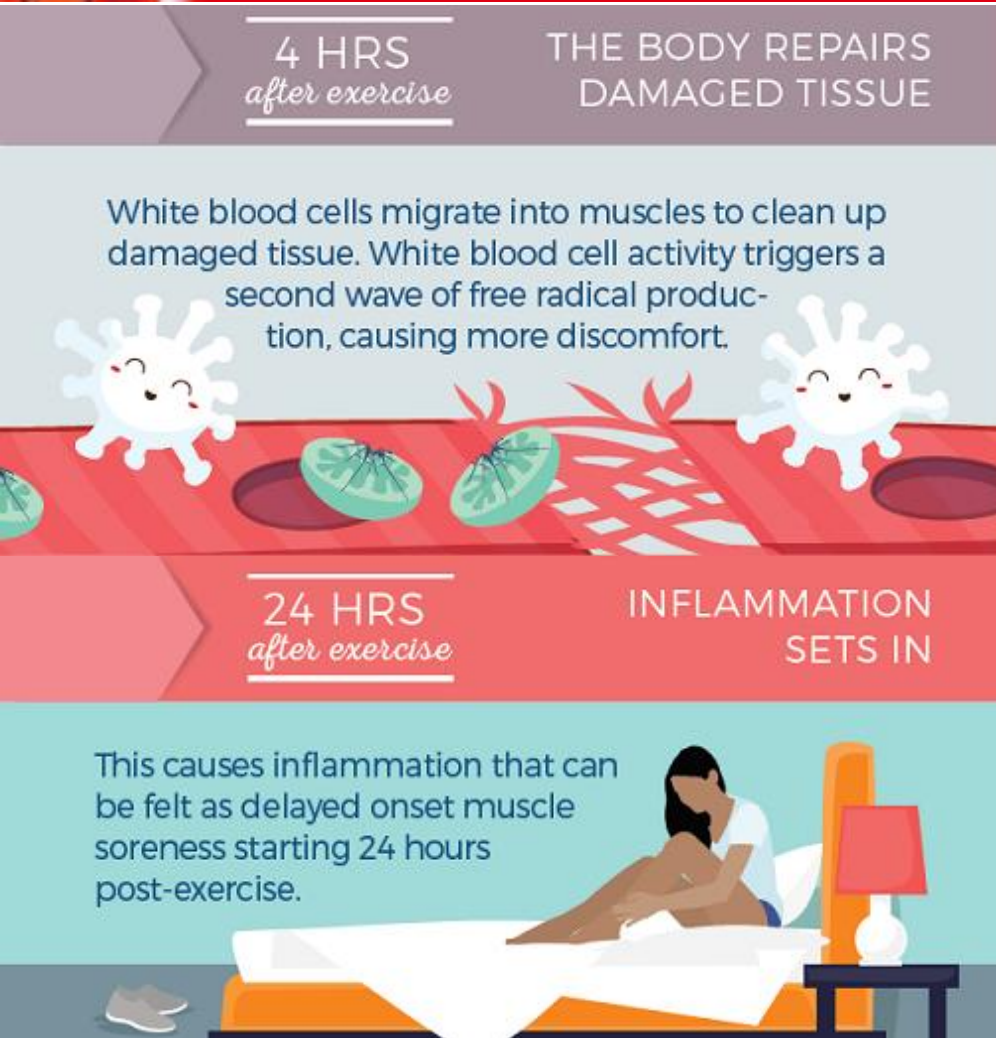
Revised from Nishida Y, et al., (2007). Carot Sci. 11: 16-20

# What Makes Astaxanthin so Unique?

## *Astaxanthin Spans Cell Membranes*



# Anti-inflammatory Properties of Natural Astaxanthin



## Proinflammatory Factors Modulated by Natural Astaxanthin

### Signaling Molecule

cytokines

IL-6  
MCP-1  
IL-8  
FKN  
IL1- $\alpha$   
TNF- $\alpha$



Also known to be secreted by muscles during exercise (myokines)

ICAM-1 increase

<b>TF Complex</b>	NFkB	Controls expression of cytokines, Cell Adhesion Molecules, ...
<b>Bioactive lipid</b>	PGE2	Activates PGC-1 $\alpha$ , SOD increase
<b>Hepatic protein</b>	CRP	Marker of systemic inflammation



# Natural Astaxanthin for Muscle Recovery

## Natural Astaxanthin Abates

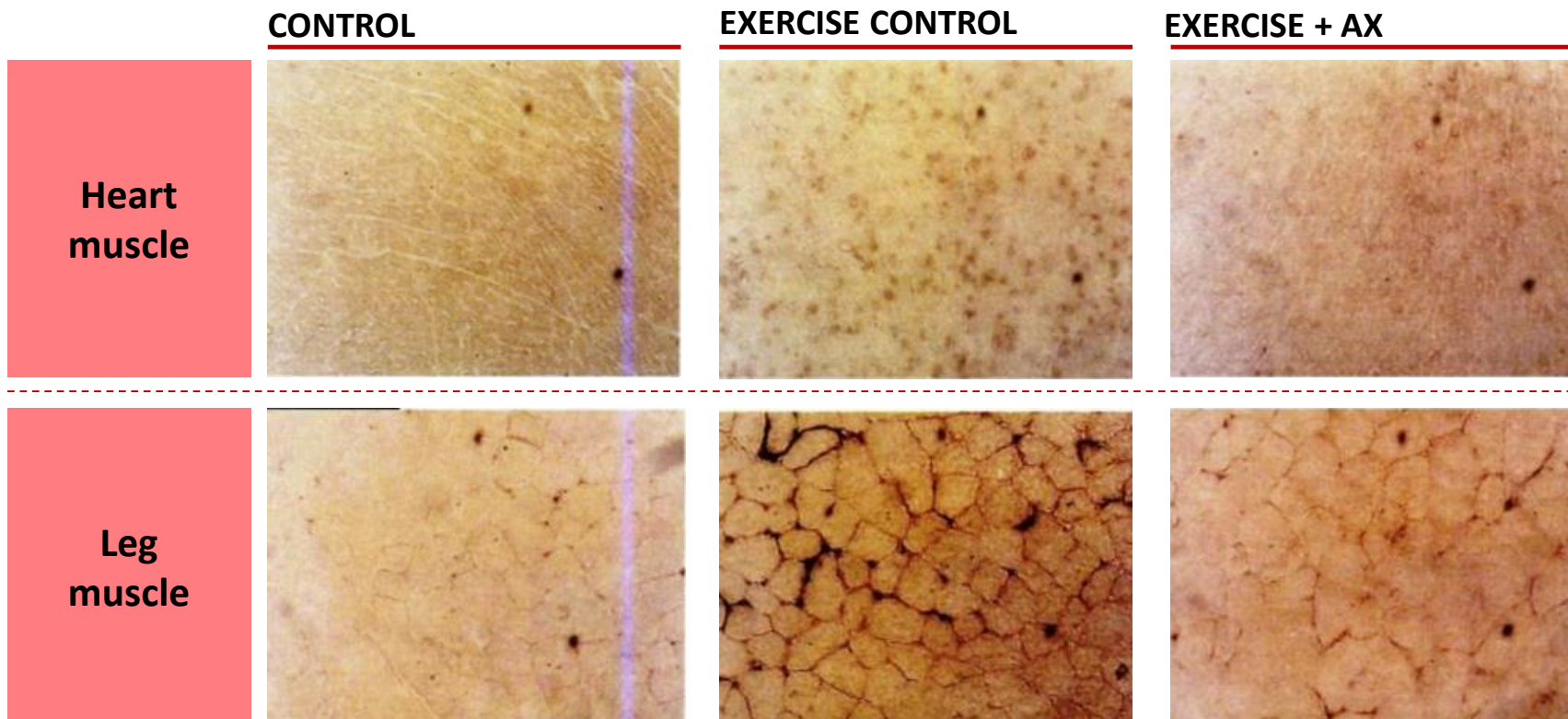
- Muscle Damage
- Exercise-induced inflammation
- Soreness



# Astaxanthin Protects Muscle from Damage

## Astaxanthin limits the damage of heart muscle and leg muscle from oxidation

Fat oxidation during exercise    0.02% astaxanthin for 3 weeks



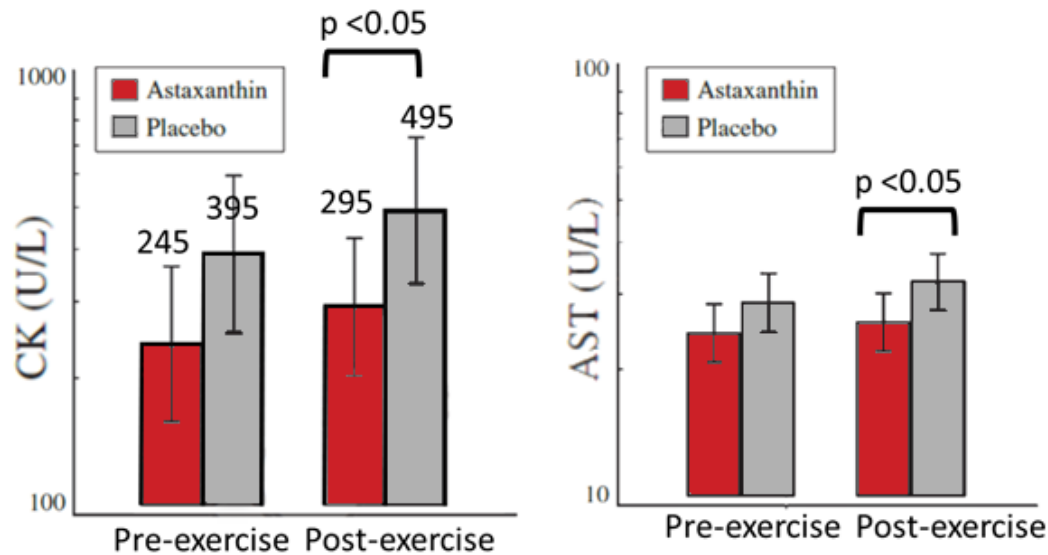


# Astaxanthin Protects Muscles from Free Radical Damage & Exercise-Induced Inflammation



Baralic et al. Evidence-Based Complementary and Alt. Med. 2015 (4): 1-9 (2015).

## AstaReal® Astaxanthin Reduces Muscle Damage



Djordjevic et al., The Journal of sports medicine and physical fitness 52(4):382-92 (2012).

32 elite soccer players (avg 18 y.o.)  
 14 in placebo group  
 18 taking 4mg/day **AstaReal® Astaxanthin**





# Competitive Cyclists Feel the Difference

I felt that AstaReal helped decrease muscle soreness after high intensity workouts and sped up my recovery.

Daniel Z.  
San Rafael, CA  
Competing 20 years

I found that AstaReal helped me with recovery. ... I found that while using AstaReal this period of discomfort seemed shorter and less intense.

AstaReal gave my overall sense of wellbeing a boost. It seemed to allow me to train harder especially on consecutive days, and go deeper in races. Muscle soreness after workouts was reduced.

James S.  
New York, NY  
Competing 10 years

Maria Q.  
San Rafael, CA  
Competing 11 years

Survey of 146 consumers



# Competitive Rower Feels the Difference

## *The Seventy48*

48 hours to complete 70 miles  
Race from Tacoma, WA to Pt. Townsend, WA.

June 11<sup>th</sup>, 2018

When I took astaxanthin, it helped my body heal, it helped my body recover, and it also gave me the energy that I needed, when I needed it.

My body doesn't feel exhausted after training or rowing. I feel great.

Sue O.  
Age 55  
Rower

- Sue took AstaReal® Astaxanthin 2 months before the race.
- Sue's team completed the race in 26 hours.
- 2 days later, Sue was back out rowing.



# Natural Astaxanthin for Endurance

## Natural Astaxanthin Boosts

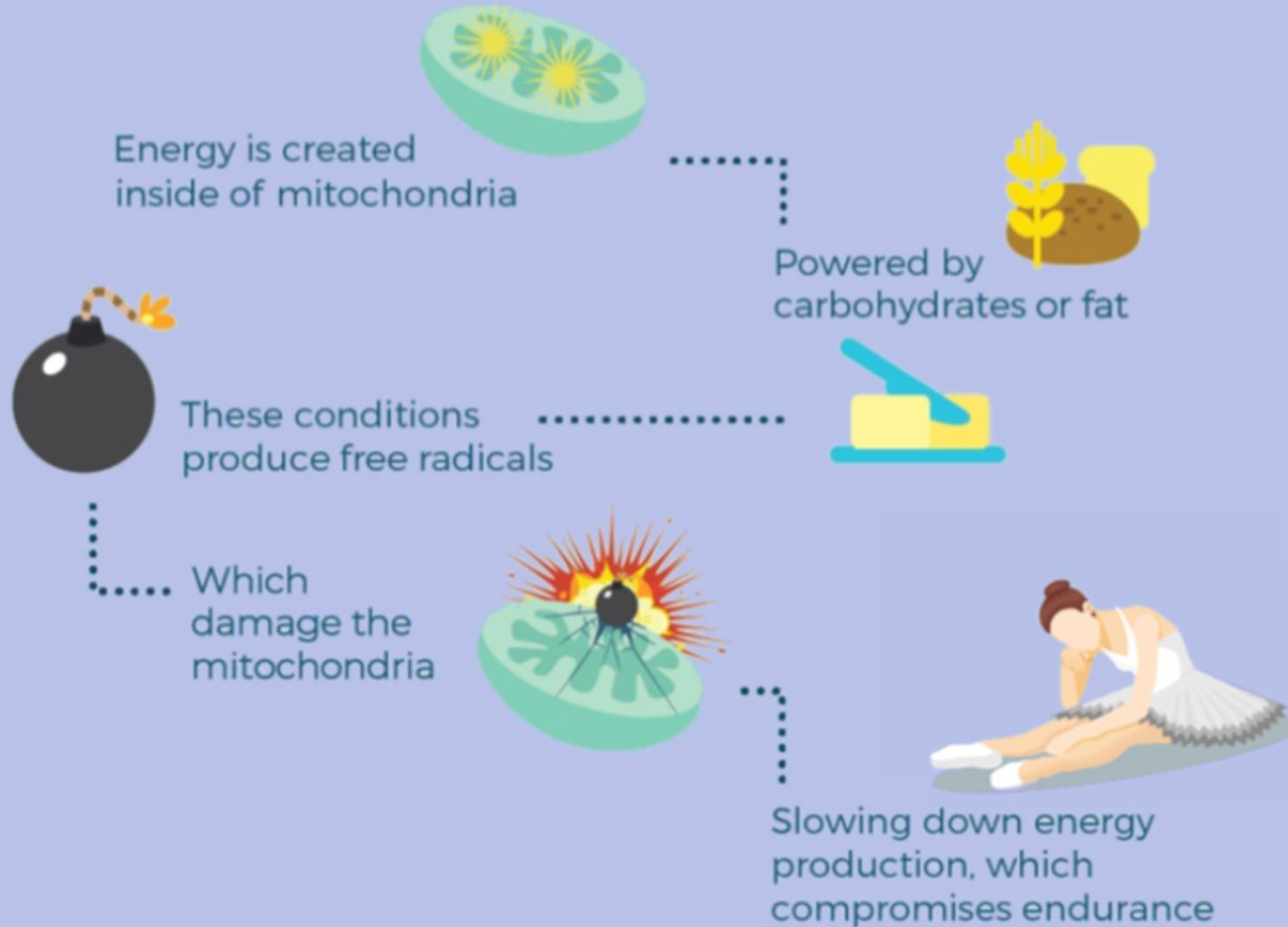
- Energy Production
- Power Output





# Energy and Free Radicals Made by Mitochondria

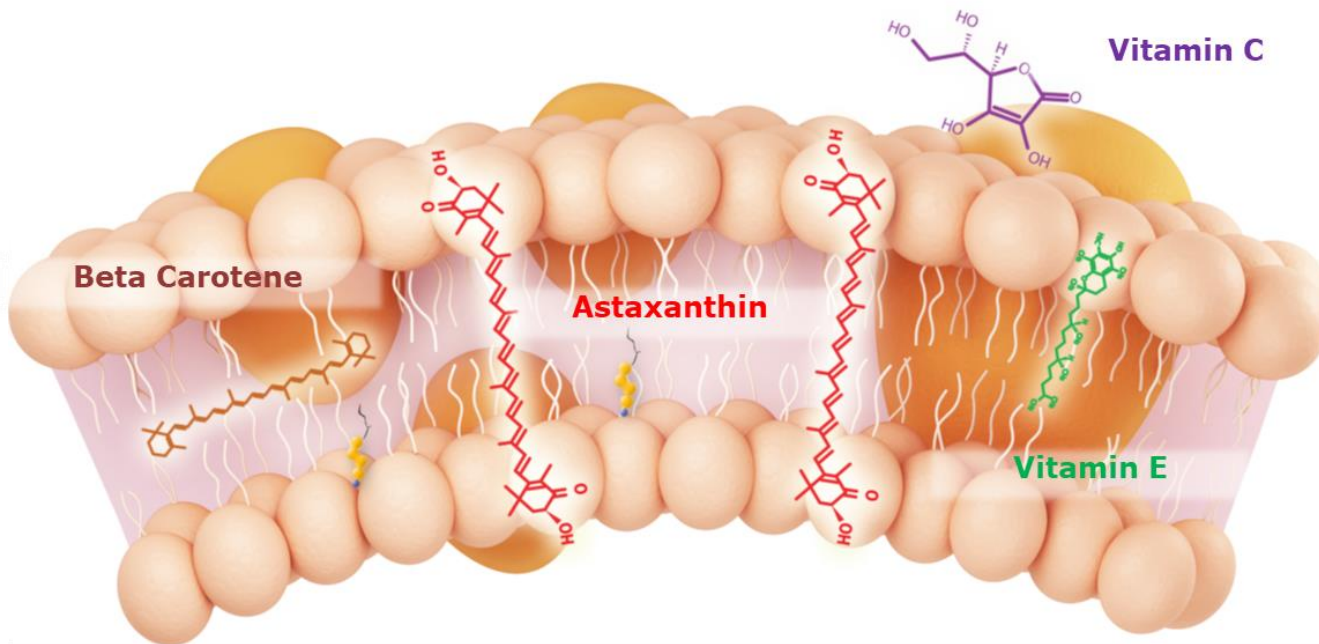
## *Aerobic Energy Production During Exercise*



# What Makes Astaxanthin So Unique?

## ***Astaxanthin Spans Cell Membranes***

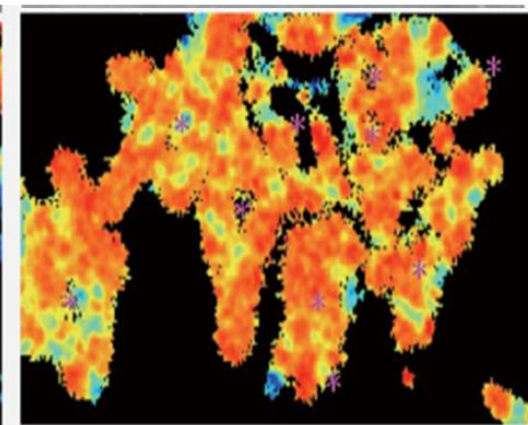
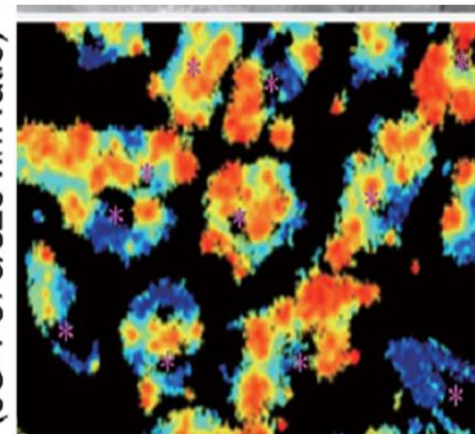
35-50% deposits in mitochondrial membranes



Non-Treated Group

Astaxanthin-Treated Group

Membrane Potential  
(JC-1 570/520 nm ratio)



Low  High  
Mitochondrial membrane potential

Mitochondrial membrane potential. Membrane potential images of HeLa pre-treated with 800 nM AX for 2 days and then exposed to 30 ug/mL antimycin A for 15min.

Wolf et al (2010) J of Nutr Biochem vol 21;381-389

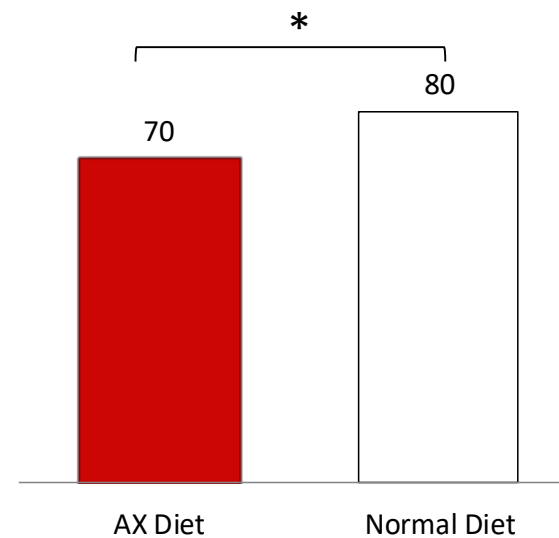
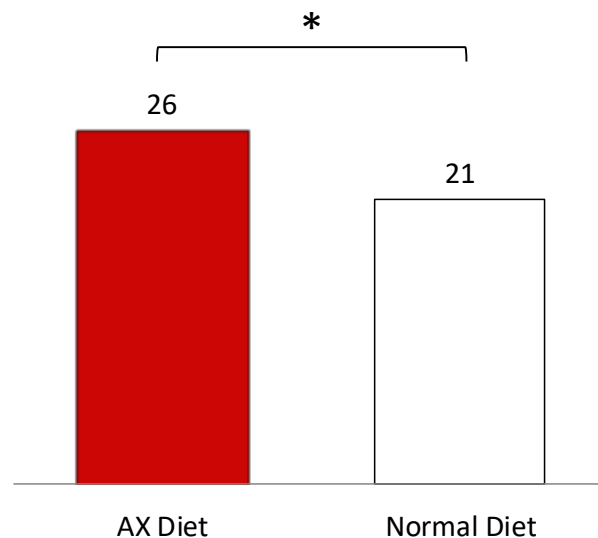
# Astaxanthin Facilitates Fat Utilization During Exercise

Mice trained to perform treadmill running at 25 m/min for 60 min after 4 week of supplementation with astaxanthin chow (0.02% w/w).

Fat was used preferentially as the Energy substrate during exercise

Fat utilization(mg/kg/min)

Carbohydrate Utilization(mg/kg/min)



n=8; \*p < 0.05

Aoi et al., Biochemical and Biophysical Research Communications 366(2008) 392-897



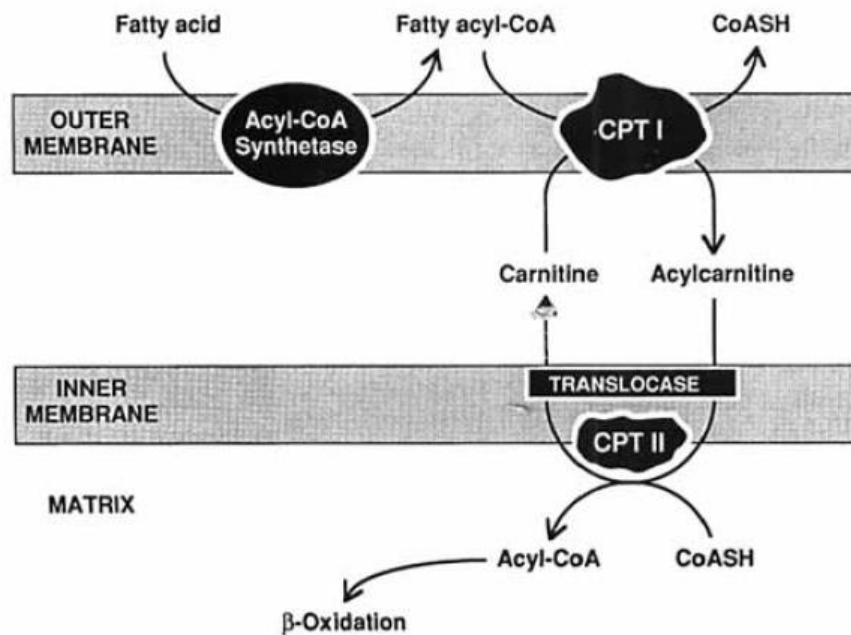
# Astaxanthin Modulates Key Regulators of Fat Oxidation in Muscle

**Carnitine palmitoyltransferase 1 (CPT1)** is the rate-limiting enzyme in fat oxidation.

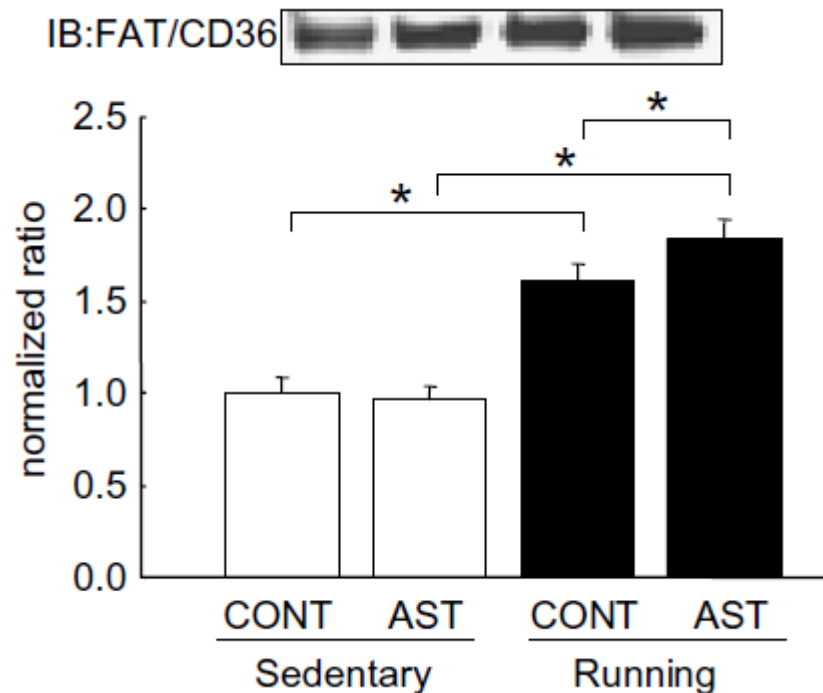
Catalyzing the transfer of the acyl group to L-carnitine.

**Endurance exercise training increases association of mitochondrial FAT/CD36 and CPT1 in skeletal muscle to increase resting fat oxidation.**

Schenk and Horowitz. Am J Physiol Endocrinol Metab 291: E254–E260, 2006



**Astaxanthin Supplementation Increased Association of FAT/CD36 and CPT1 more than exercise alone.**

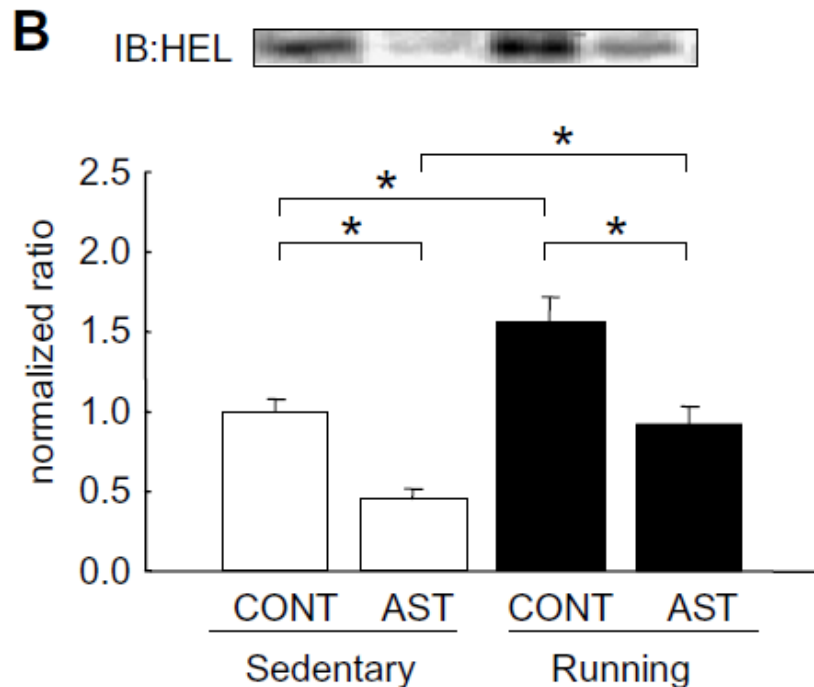


Muscle protein lysate collected immediately after 30 m/min for 30min on final day. n=6; \*p<0.05

# Astaxanthin Reduces CPT1 Oxidation During Exercise

## Astaxanthin Reduced Oxidative Modification of CPT1 via Hexanoyl-Lysine Adduct Formation (HEL) in Both Exercising and Sedentary Mice.

Muscle protein lysate collected immediately after 30 m/min for 30min on final day.



n=6; \*p<0.05

## Astaxanthin Increased Muscle Glycogen, Reduced Plasma Lactic Acid Compared to Running Control

	Sedentary		Running	
	CONT	AST	CONT	AST
Plasma lactate (mM)	2.5 ± 0.1	2.5 ± 0.1	4.3 ± 0.3*	3.5 ± 0.2*.#
Muscle glycogen (mg/g tissue)	3.7 ± 0.1	3.8 ± 0.2	2.3 ± 0.1*	2.7 ± 0.1*.#

After 30 m/min for 30min on final day.

n=8; \*p<0.05 difference from sedentary;

# p<0.05 difference from control diet

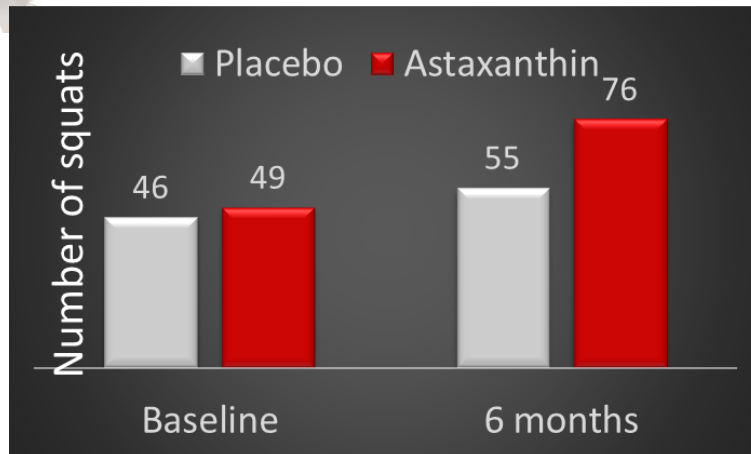
# Astaxanthin Helps Improves Muscle Performance & Power Output

40 healthy paramedic students (ages 17-19) undergoing strength and endurance training  
20 treated with placebo  
20 treated with 4 mg/day **AstaReal® Astaxanthin**

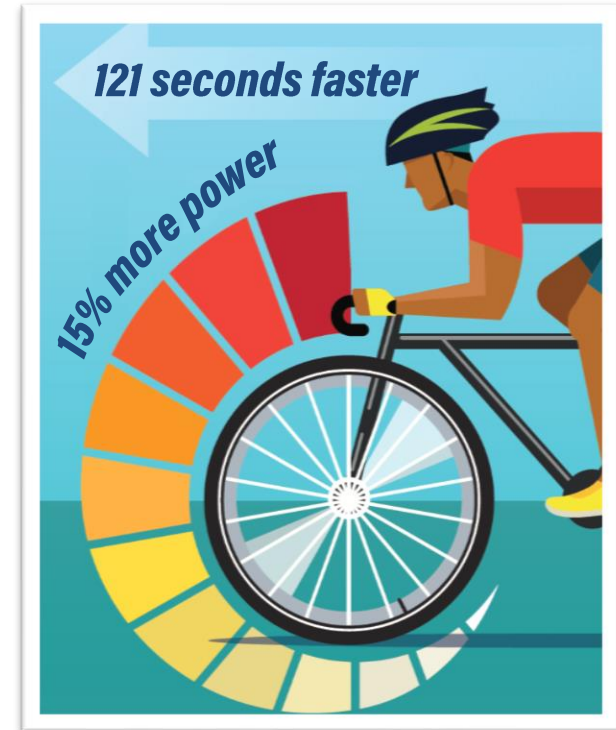


14 competitive cyclists (ages 18-39) had their performance tested in a 20km timed trial  
7 cyclists with placebo  
7 cyclists with 4mg/day **AstaReal® Astaxanthin** for 4 weeks

**AstaReal® Astaxanthin Boosts Strength/Endurance Training**



Malmsten, et al., *Carotenoid Science*, 13, 20-22 (2008).



Earnest, et al., *Int J Sports Med.*, 32 (11): 882-8 (2011).

AstaReal® Astaxanthin group:

- 121 sec improvement (5%) in average time.
- 20W increase (15%) in average power output.

Placebo group:

- 19 sec improvement (0.8%) in average time.
- 1.6W increase (0.5%) in average power output.



# Additional Benefits for Skin and Healthy Aging

Opportunities for Tailored Products

## Natural Astaxanthin for Healthy Aging and for Beauty

- Protecting Collagen Production
- Staying Strong with Astaxanthin & Exercise in Later Years

# Astaxanthin Supports Skin Resilience

Sweat and the elements can take a toll on skin over time.



Astaxanthin taken orally enters the bloodstream and reaches all skin layers.

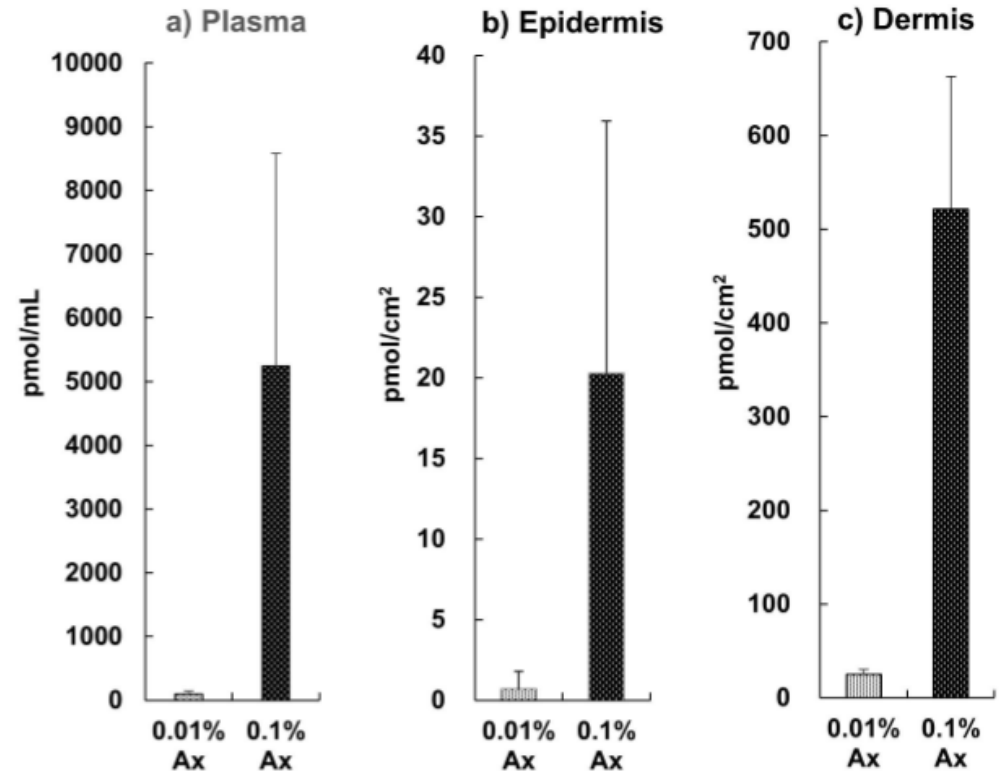
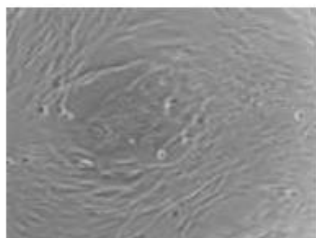


Fig 5. Astaxanthin concentration in the plasma and skin (epidermis and dermis) of the hairless mice. Data represent the means  $\pm$  SD (n = 5). Bars with matching letters are significantly different from each other at  $P < 0.05$ .

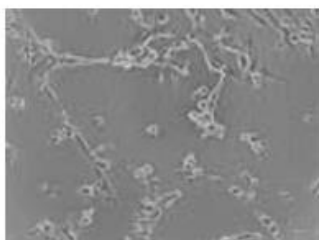
mice fed 0.01% or 0.1% astaxanthin in mouse chow for 70 days Komatsu T, et al., 2017. PLoS ONE 12(2): e0171178.

# Astaxanthin Protects Collagen Production

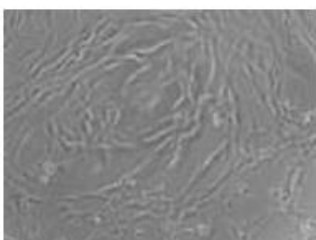
**AstaReal® Astaxanthin** protects human skin fibroblasts from ROS *in vitro*



Non singlet oxygen exposure



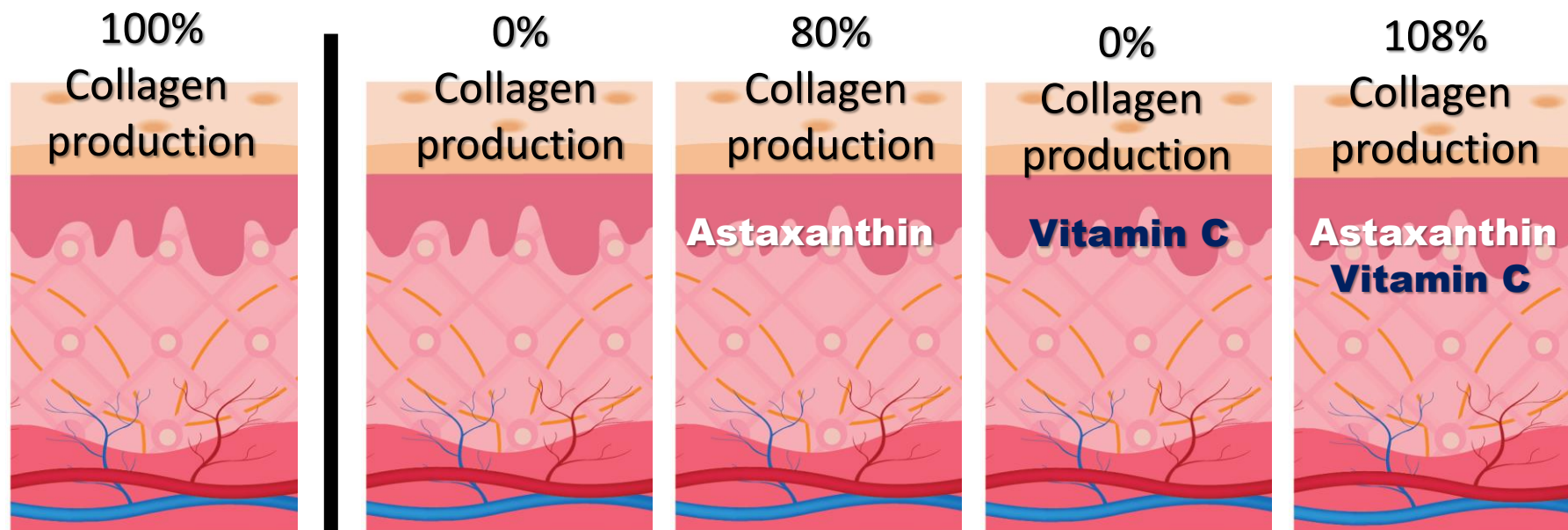
Singlet oxygen exposure



Singlet oxygen exposure+Ax 3µM



## ROS



Free radical exposure abolishes collagen synthesis

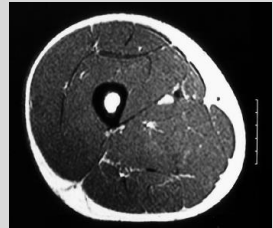
**AstaReal® Astaxanthin** preserves up to 80% of collagen synthesis

Tominaga K. et al., 2009 Food Style 21 13(1):84-86  
Tominaga K et al. 2009 Food Style 21. 13(10)25-9

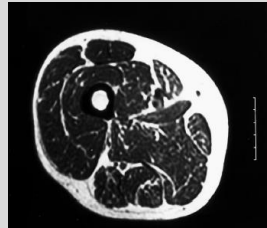




# The Impact of Aging on Muscle Health



< 40 yrs



> 65 yrs

- Muscle mass declines at approximate 1% per year after the age of 30 years.

Kirk-Sanchez and McGough. Clinical Interventions in Aging 2014:9



## Conceptual stages (definition by EWGSOP)

	Muscle mass	Strength	Performance
Pre-sarcopenia	↓		
Sarcopenia	↓	↓ or	↓
Severe sarcopenia	↓	↓	↓

## Incidence of falls in community-dwelling individuals:

- 30% of those aged 65+
- 50% of those aged 85+
- Of those who fall, 12% - 42% will have a fall-related injury.

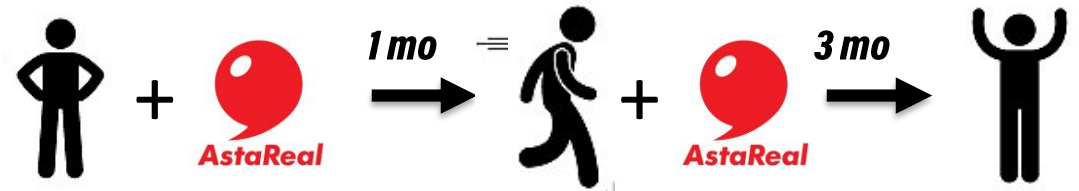
Prevention of Falls and Fall-Related Injuries – Ontario Health Technology Assessment Series 2008;8(2)

- USDA recommends 1/4 plate protein, 1/4 plate whole grains, and 1/2 plate vegetables and fruits.
- 20-30 minutes of resistant training 3x a week or 30 min walk.
- Astaxanthin to boost training and antioxidant capacity

# Healthy Aging – Exercise Plus Astaxanthin Improved Mobility

42 subjects (ages 65-85) had strength & endurance tested  
19 subjects treated with placebo  
23 subjects treated with **12mg/day AstaReal® Astaxanthin**  
for 4 months

Clinical evidence shows **AstaReal® astaxanthin** together with exercise works better for building **strength** compared to exercise alone.



14.4%

increase in maximum voluntary contraction (MVC;  $p < 0.02$ )

2.7%

increase in tibialis anterior cross-sectional area (CSA;  $p < 0.01$ )

11.6%

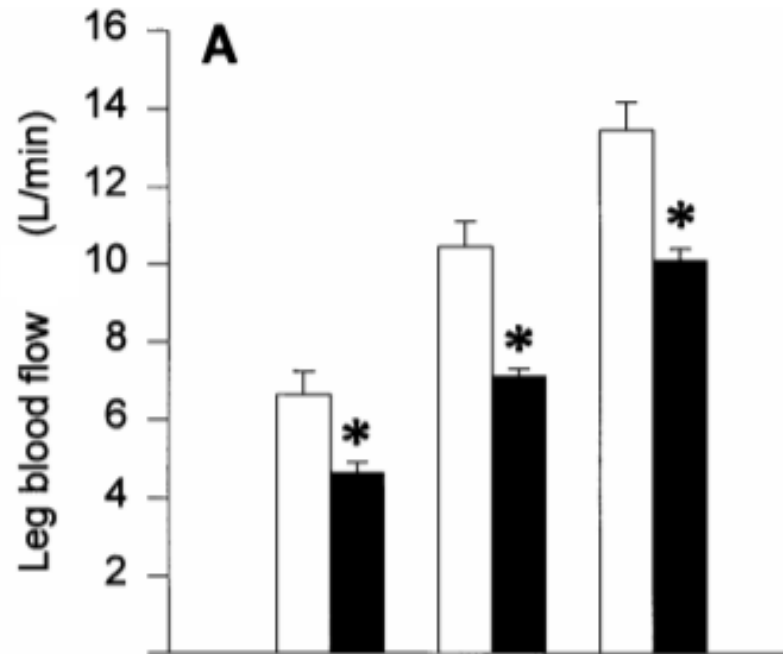
increase in specific force (MVC/CSA;  $p = 0.053$ )



# The Effect of Aging on Circulatory Adaptation

Fit older men studied had 25% lower leg blood flows at the three submaximal work rates assessed.

leg cycle ergometer exercise



- Exercise promotes circulatory adaptation/compliance
- But endurance trained men (~63 y.o.) still not to the same level as their trained younger counterparts (27 y.o.)

Exercise alone may not be enough to allow O<sub>2</sub> matching

O<sub>2</sub> Demand

O<sub>2</sub> Delivery



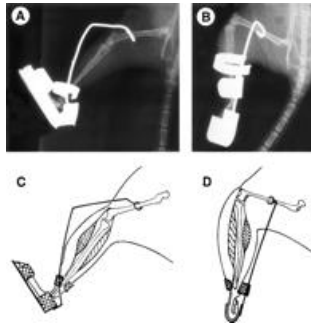
- Astaxanthin inhibits capillary regression in hindlimb unloaded mice.
- Astaxanthin supports blood rheology and blood flow
- Astaxanthin boosts effect of functional training in older individuals (65-85 y.o.)



# Astaxanthin inhibits regression of capillary network in the atrophied muscle

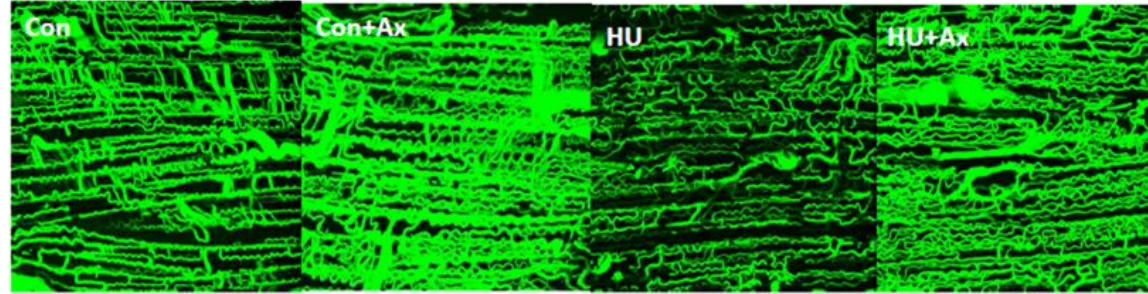
## Study summary

- Oral administration of astaxanthin daily (50mg) followed by 7 days immobilization (hindlimb unloading)
- **HU**- hindlimb unloading

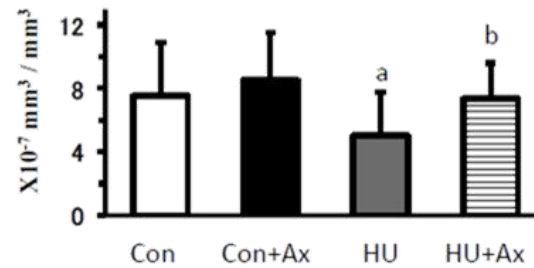


## Result

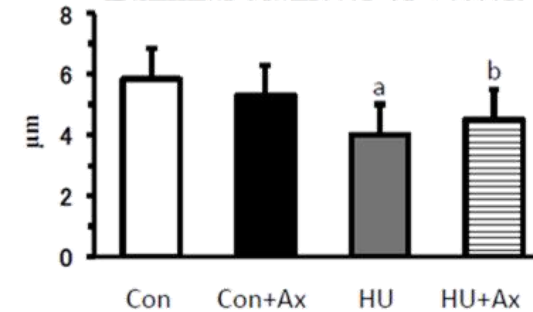
### 3-D capillararity in skeletal muscle



### Capillary Volume



### Luminal diameter of Vessels



a; compared with Con, p < 0.05  
b; compared with Con, p < 0.05

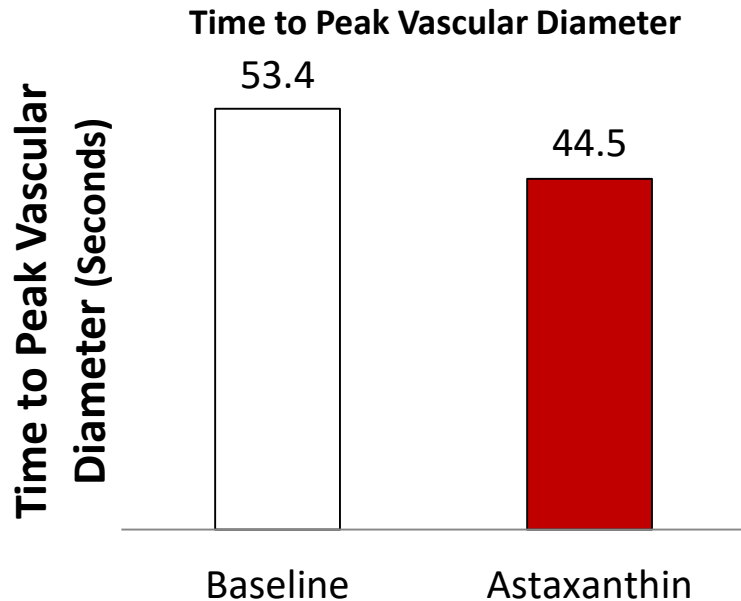
Physiotherapy Volume 97. BENEFICIAL EFFECT OF NUTRITIONAL SUPPORT AGAINST REGRESSION OF CAPILLARY NETWORK IN ATROPHIED SLOW MUSCLE. Kanazashi et al Kobe University Graduate School of Health Sciences, Department of Rehabilitation Sciences

# Astaxanthin Supports Blood Vessel Compliance and Promotes Larger Lumen

## Vascular resilience

### Human Study

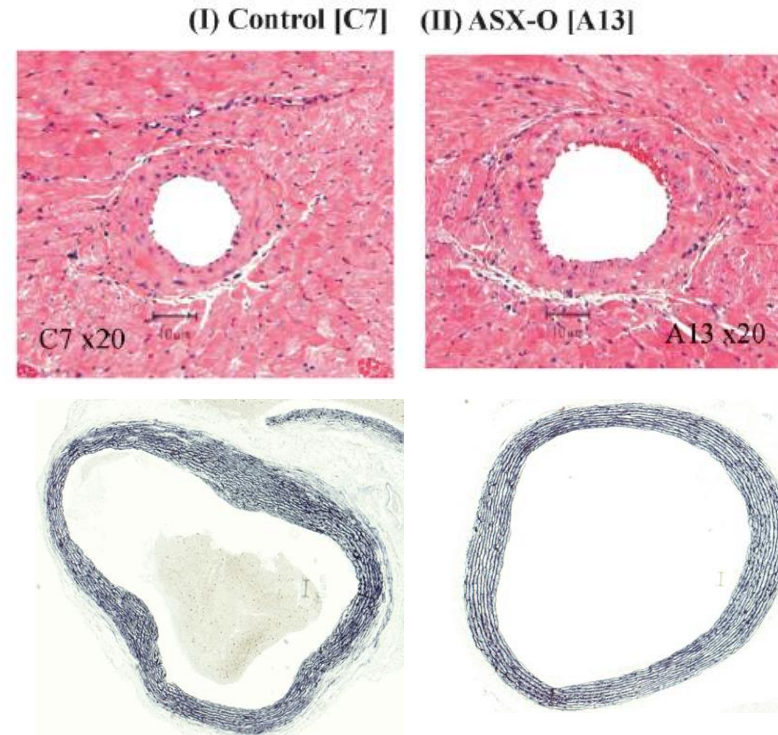
- Open Label Clinical Study
- 35 healthy postmenopausal women (BMI 22.1)
- Treated with astaxanthin daily dose of 12 mg for 8 weeks.



Source : A0103 Iwabayashi et al. Anti-Aging Medicine 6 (4) : 15-21, 2009

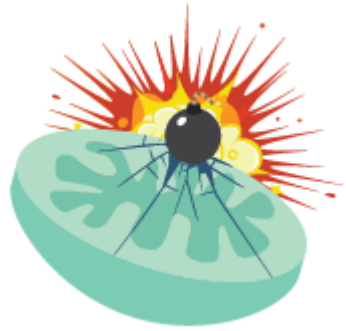
### Animal Study

- Hypertensive Rats ingested 5mg astaxanthin daily x 7 weeks



Source: G. A0091 Hussein, et al. Biol. Pharm. Bull. 28(1) 47-52 (2005).

# Summary of Mechanism of Action for Astaxanthin



- Mitochondrial protection via antioxidant properties

- Fat utilization by modulating CPT1



- Promoting Blood Vessel Compliance and Blood Flow

- Reducing Exercise-induced muscle damage (CK, AST)

- Anti-inflammatory properties reducing DOMS (CRP)

- Boosting the effect of functional training (paramedics, sarcopenia, cyclists)





# Thank you!



Karen Hecht  
[khecht@astarealusa.com](mailto:khecht@astarealusa.com)

