SCIENCE DRIVEN NUTRITION: CISSN STUDY GUIDE

1. Explain how carnosine is synthesized within the body
   a. Carnosine (B-alanyl Histidine) is made in the body from histidine and B-alanine via an energy dependent reaction catalyzed by carnosine synthetase.
   b. Found in skeletal muscle, cardiac muscle, brain, kidney, and stomach.
   c. Available in meats and absorbed in intestine via peptide transporters
   d. Antioxidant activity, (hydroxyl and superoxide radical) and oppose glycation.
   e. Suppress lipid peroxidation and react with protein carbonyl
   f. Regulates intracellular calcium and contractility in muscle
   g. Primarily, carnosine with pH buffering capacity is widely used in the field of sports nutrition. Because the dissociation exponent (pKa) of carnosine is 6.83, it is suggested that carnosine attenuates the reduction in blood pH by a large amount of H⁺ originating from the dissociation of lactic acid during strenuous exercise, and suppresses a loss of force.

2. What is a waxy maize starch and what effect does it have on blood glucose?
   a. A highly branched starch called amylopectin. Water soluble and absorbed by the gut more quickly than dextrose or maltodextrin, research has not substantiated this claim.
   b. Has been shown to be absorbed with less insulin, allowing ketogenic affects to remain, increase both glycogen and FFA substrate utilization.

3. Based on recent studies, which vitamin shows evidence of positively affecting muscle function?
   a. Vitamin D

4. What is needed for gluconeogenesis in humans? Give examples of gluconeogenic precursors
   a. Gluconeogenesis relies upon lactate, pyruvate, glycerol (a catabolic produce of triaglycerols) and certain amino acids (glutamine and alanine)

5. What effect does long-term coffee consumption have on Type II Diabetes?
a. Results suggest that moderate consumption of both caffeinated and decaffeinated coffee may lower risk of type 2 diabetes in younger and middle-aged women. Coffee constituents other than caffeine may affect the development of type 2 diabetes.

6. **What effect does supplementing with WPI have on muscle damage?**
   a. The major finding of this investigation was that whey protein isolate supplementation attenuated the impairment in isometric and isokinetic muscle forces during recovery from exercise-induced muscle injury.
   b. The current study demonstrates that whey protein in a partially hydrolysed (pre-digested) form improves strength recovery rates, possibly due to an increase in the rate of repair processes and/or a reduction in the extent of damage, from intense training, in particular, eccentric exercise that is commonly used in weight training.

7. **When glycogen stores are depleted, what macronutrient becomes the predominant fuel source during distance running?**
   a. Fat (oxidation)

8. **How many extra kcals are required for accumulation of 1kg of body fat?**
   a. Approximately 7000

9. **What are the effects of pre-exercise dehydration on thermoregulation and performance?**
   a. Decreased thermoregulation and performance.

10. **What are the effects of L-alanyl-L-Glutamine supplementation on time-to-exhaustion and dehydration stress?**
    a. Results demonstrate that AG supplementation provided a significant ergogenic benefit by increasing time to exhaustion during a mild hydration stress. This ergogenic effect was likely mediated by an enhanced fluid and electrolyte uptake.

11. **What effects can a low-carbohydrate diet have on prolonged physical activity.**
    a. Decreased glycogen synthesis, decreased performance, overreaching/overtraining.
12. **Approximately how many days of heat exposure does it take to fully acclimate to exercising in the heat?**
   
a. Complete acclimation takes up to 14 days

13. **What is HICA and what are the effects of its supplementation for a period of 4 weeks?**
   
a. Alfa-Hydroxy-isocaprio acid (HICA) is an end product of leucine metabolism in human tissues such as muscle and connective tissue. According to the clinical and experimental studies, HICA can be considered as an anti-catabolic substance. The present study investigated the effects of HICA supplementation on body composition, delayed onset of muscle soreness (DOMS) and physical performance of athletes during a training period.

   b. Already a 4-week HICA supplementation of 1.5 g a day leads to small increases in muscle mass during an intensive training period in soccer athletes.

14. **What is a Bod-Pod**
   
a. A body composition recording device that uses Air Displacement Plethysmography.

15. **Compare fat and carbohydrate oxidation during exercise. Under what conditions does one fuel source predominate over the other**
   
a. Fat oxidation primarily occurs at low intensity long duration exercise

   b. Carbohydrates are oxidized preferentially during higher intensity exercise

16. **What effect does betaine supplementation have on exercise performance?**
   
a. Betaine supplementation may positively affect exercise performance through favorable lactate and preferential fatty acid substrate metabolism

   b. Has been down to increase power, force, and maintenance

17. **Chronic heavy resistance training causes what adaptations in skeletal muscle**
   
a. Increase in muscle strength and size (hypertrophy)

   b. Greater increase in type II muscle fibers

   c. Shift in fiber type IIx to IIa
18. **Regular aerobic training causes what adaptations in skeletal muscle**
   a. Increased oxidative capacity, increased number and size of mitochondria, increase in enzymes of metabolic pathways involved in oxidative metabolism
      i. Succinate dehydrogenase, malate dehydrogenase, (krebs cycle tricarboxylic acid cycle)
   b. Induces a shift toward lipid metabolism transition from IIX to IIa

19. **What has the greatest effect on the sedentary person’s daily energy expenditure**
   a. Resting Metabolic Rate

20. **What activities or sports use ATP-PCr energy system as the main energy system?**
   a. Short, high intensity sports. I.E. sprinting, power lifting, high-jump, long-jump

21. **What dose of creatine, after creatine loading, will maintain elevated creatine levels for 28 days?**
   a. A typical creatine supplementation protocol of either a loading phase of 20 to 25 g CM/d or 0.3 g CM/kg/d split into 4 to 5 daily intakes of 5 g each have been recommended to quickly saturate creatine stores in the skeletal muscle. However a more moderate protocol where several smaller doses of creatine are ingested along the day (20 intakes of 1 g every 30 min) could be a better approach to get a maximal saturation of the intramuscular creatine store. In order to keep the maximal saturation of body creatine, the loading phase must be followed by a maintenance period of 3-5 g CM/d or 0.03 g CM/kg/

22. **What role do vitamins play in metabolism?**
   a. Vitamins are the building blocks/precursors to cell parts and enzymes involved in substrate metabolism

23. **Where does most of the energy for ATP phosphorylation come from?**
   a. From the energy in the chemical bonds of the food we ingest

24. **What does pre-exercise ingestion of glycerol do?**
25. **What is the glucose-alanine cycle? What is the Cori-cycle?**
   a. Glucose-alanine cycle
      i. During exercise, pyruvate is formed from the breakdown of glyocgen and glucose. Within the muscle, BCAAs donate their amino group to pyruvate to form alanine. Alanine is transported to the liver where it is used to regenerate glucose. Glucose can then be transported back to skeletal muscle to be used for energy. Thus, BCAAS (especially leucine) help reform glucose during fasting and prolonged exercise
   b. Cori-Cycle
      i. The metabolic pathway in which lactate produced by anaerobic glycolysis in the muscles moves to the liver and is converted to pyruvate and then to glucose via gluconeogenesis, which then returns to the muscles and is converted back to lactate

26. **Why is fat considered the ideal cellular fuel?**
   a. It produces a far superior amount of energy when oxidized vs carbs or protein

27. **What are the essential amino acids? What are some conditionally essential amino acids**
   a. Essential Amino Acids are AA that can not be synthesized by the body and must be consumed in our diet *are BCAA
      i. Histidine
      ii. Isoleucine*
      iii. Leucine*
      iv. Lysine
      v. Methionine
      vi. Phenylalanine
vii. Threonine
viii. Tryptophan
ix. Valine*
b. Conditionally Essential Amino Acids (under stressful conditions such as exercise)
i. Arginine
ii. Cysteine
iii. Glutamine
iv. Glycine
v. Proline
vi. Tyrosine

28. What is the process of glycogen synthesis called?
a. Glycogenesis

29. What is the main function of a carbohydrate
a. Energy source

30. Compare and Contrast creatine monohydrate and creatine ethyl ester
a. In conclusion, when compared to creatine monohydrate, creatine ethyl ester was not as effective at increasing serum and muscle creatine levels or in improving body composition, muscle mass, strength, and power. Therefore, the improvements in these variables can most likely be attributed to the training protocol itself, rather than the supplementation regimen.

31. What is the primary fuel source for high-jump? 1500 meter run? Marathon
a. High Jump: ATP/Creatine Phosphate, CHO
b. 1500 Meter Run: Glycogen, some Fat Oxidation
c. Marathon: Fat Oxidation

32. Know the equivalent kcal values 1g CHO, lipid, protein
a. CHO= 4kcal/g
b. Lipid=9kcal/g
c. Protein = 4 kcal/g

33. **What is beta-alanine and what does it do when ingested during intense training?**
   a. Beta-alanine is the rate-limiting enzyme in the synthesis of carnosine. In other words, the amount of carnosine your body produces is directly dependent on the amount of beta-alanine available. Without sufficient beta-alanine, carnosine synthesis is limited.
   b. Supplementation with beta-alanine appears to have the ability to augment performance and stimulate lean mass accrual in a short amount of time (8 weeks) in previously trained athletes. β-alanine may magnify the expected performance outcomes of training programs with different metabolic demands.

34. **What are the effects of creatine supplementation?**
   a. Creatine monohydrate is the most effective ergogenic nutritional supplement currently available to athletes in terms of increasing high-intensity exercise capacity and lean body mass during training.
   b. Creatine monohydrate supplementation is not only safe, but possibly beneficial in regard to preventing injury and/or management of select medical conditions when taken within recommended guidelines.
   c. Creatine monohydrate has been reported to have a number of potentially beneficial uses in several clinical populations, and further research is warranted in these areas.

35. **What is the SI unit for Energy?**
   a. The Joule
   b. 1 kcal = 4.2 joule

36. **What is sweat and where does it come from**
   a. The production of a fluid consisting primarily of water as well as various dissolved solids (chiefly chlorides), that is excreted by the sweat glands in the skin of mammals.[1] Sweat contains the chemicals and small amounts of urea.

37. **Which activities or sports use aerobic energy as the main energy system?**
a. Long duration, low relative intensity events
   i. Cycling, long distance running, long distance rowing

38. **What is protein and what is it used for in the body?**
   a. Protein is one of the three macronutrients, an amino acid, and a source of fuel
   b. Vital to health
      i. Component of DNA, RNA, insulin, hemoglobin, epinephrine, and serotonin
      ii. Enzymes, A/B balance, transportation, Antibodies

39. **What are skeletal muscle satellite cells? What are their functions?**
   a. Satellite cells of skeletal muscle are quiescent, myogenic stem cells located outside the myofiber sarcolemma but within its basement membrane. Greater in oxidative muscles
   b. Repair myofiber damage and regenerate necrotic myofibers.
   c. Fiber damage induces satellite cell activation by various mitogens.
   d. Also activate during fiber-type transformation

40. **Describe the effects of aerobic exercise on resting and exercise HR, Q, and SV. What are the effects on cardiac muscle?**
   a. Resting HR: decreases
   b. Exercise HR: no change
   c. Q?
   d. SV: increased
   e. Effects on cardiac muscle: increase

41. **Describe the difference between glycemic load and glycemic index?**
   a. Glycemic index is a ranking system that is used to compare the acute glycemic impact of foods. 2-hour glucose response curve is compared with 50g of CHO of reference food
   b. Glycemic load is the product of the glycemic index and the CHO content in a serving, represents both quality and quantity of CHO

42. **Which A.A. is considered to be the most naturally abundant in plasma and skeletal muscle?**
a. Glutamine
   i. Catabolic states of injury and illness, glutamine becomes conditionally-essential (requiring intake from food or supplements). Glutamine has been studied extensively over the past 10–15 years and has been shown to be useful in treatment of injuries, trauma, burns, and treatment-related side-effects of cancer as well as in wound healing for postoperative patients.
   ii. Results demonstrate that AG supplementation provided a significant ergogenic benefit by increasing time to exhaustion during a mild hydration stress. This ergogenic effect was likely mediated by an enhanced fluid and electrolyte uptake.

43. What nutrients improve or support immune system function?
   a. Glutamine
      i.Enhancement of protein and glycogen synthesis
      ii. Below normal glutamine levels can contribute to immune suppression in overtrained athletes and exercise participants.
   b. Protein
   c. Vitamin C
      i. Antioxidant
      ii. Assists in iron absorption
      iii. Increased vitamin C supplementation positively associated with neutrophils and lymphocytes and immune status
   d. Zinc
      i. A constituent of digestive enzymes
      ii. Enhances immune status
   e. Echinacea
      i. Enhance immune status

44. What is the thermic effect of fat? Protein? Carbohydrate?
   a. Fat: 2-3% (almost negligible)
   b. Protein: 25-30%
   c. Carbohydrate: 6-8%
45. **What is the relationship of anabolic steroid use to plasma lipids?**
   a. Decrease in HDL lipoproteins at high levels of dosage

46. **Know the difference between type I and type IIa and IIX muscle fibers**
   a. Type I
      i. Slow twitch, small MN, High FR, Aerobic, VERY High MCD, High O.C., Low GC, Triglyceride Fuel source, consume lactic acid
   b. Type IIa
      i. Moderately fast twitch, Medium MN, fairly high FR, long-term anaerobic, medium power, High MCD, high O.C., high G.C., CP and glycogen fuel
      ii. Produce lactic acid and CP
   c. Type II x
      i. Fast twitch, Large MN, intermediate FR, short-term anaerobic, high power, medium MCD, inter OC, high GC, ATP CP and little glycogen fuel
      ii. Consume CP

47. **What is lactic acid and what effect does it have on energy metabolism and exercise performance?**
   i. It is the product of fast (anaerobic glycolysis)
   ii. Decreases pH, energy metabolism, and Exercise Performance

48. **The process of splitting triglycerides is known as what?**
   a. Lipolysis

49. **What organ(s) is/are involved in nitrogen elimination**
   a. Liver
      i. The liver is the main metabolic organ utilizing amino acids for tissue protein synthesis, heme formation, pyrimidine and purine synthesis (nucleotide precursors), ketone body and carbohydrate formation, *de novo* synthesis of non-essential amino acids, and finally excrete surplus nitrogen via the urea cycle. The liver thus is the gatekeeper of the nitrogen balance in animals, its intake and excretion.
   b. Kidney
i. Nitrogen can also be excreted as ammonium. This process is controlled by the kidney and is used to control the blood plasma pH. The blood plasma pH, however, is determined by other factors as well, such as organic acids (amino acids) and carbonic acid (CO₂ levels). Ammonium metabolism in kidney functions to depose H⁺ in urine. In a first reaction, kidney enzymes deaminate glutamine in two steps to α-ketoglutarate. The first side chain deamination is catalyzed as simple hydrolysis and is not reversible.

50. During which process do amino acids loose their amine or nitrogen group and where does it happen.
   a. Transamination or oxidative deamination
      i. TA occurs when the amino group from one amino acid (NH₃⁺) is transferred to a carbon skeleton (usually alpha-ketoglutarate), forming a new amino acid (glutamate)
      ii. ODA amino group is removed, converted to ammonia and urea in the liver, and subsequently removed by the kidneys and sweat glands.
         1. Oxidative deamination occurs primarily on glutamic acid because glutamic acid was the end product of many transamination reactions.
         2. The glutamate dehydrogenase is allosterically controlled by ATP and ADP. ATP acts as an inhibitor whereas ADP is an activator.

51. What are the metabolic pathways of glucose after absorption by the small intestine?
   a. There are several metabolic pathways for carbohydrates, which include glycogenesis, glycolysis, hexosemonophosphate shunt, tricarboxylic acid cycle and gluconeogenesis
   b. 1) glucose is in part deposited in the liver and muscle in the form of glycogen. This glycogen serves as the body's carbohydrate reserve;
      2) a part of glucose serves for the synthesis of other substances (e.g.,
glucoproteins, glucolipids);
3) a part of glucose enters the cells, where it is degraded in the tricarbon acid cycle (Krebs cycle) to CO\textsubscript{2} and water, whereby energy is released; and
4) the fourth part of glucose is transformed to fat and deposited in adipose tissue.

52. **What are the functions of Vitamin C, E, and beta-carotene**
   a. Vitamin C
      i. Collagen synthesis
      ii. Precursor to carnitine: transport molecule for fatty acids to mitochondria
      iii. Antioxidant and recycles Vitamin E back to its reduced state
   b. Vitamin E
      i. Antioxidant
         1. Most abundant in body is alpha-tocopherol
         2. Scavenger of peroxyl radicals and inhibits lipid peroxidation in cell membranes (oxidative damage)
   c. Beta Carotene
      i. Precursor to vitamin A
      ii. Antioxidants that neutralize free radicals such as singlet oxygen and peroxyl radicals

53. **What is/are the mechanisms for caffeine’s ergogenic effect during high intensity, endurance exercise?**
   a. Thought to increase fat oxidation and spare glycogen....
   b. Increase concentration of hormone-like substances in the brain called B-endorphins during exercise
      i. Affect mood, reduce perception of pain,
   c. Delay fatigue by blocking adenosine receptors in the brain
      i. Adenosine is produced during exercise and inhibits the release of dopamine

54. **What acts as an antioxidant within the respiratory chain?**
a. Glutathione

55. **How does dietary fiber reduce the amount of food that may be absorbed?**
   a. Insoluble fiber can bind to molecules and prevent them from being absorbed
   b. Soluble becomes “gel like” and slows rate of food passage, increasing nutrient absorption…. Or irritating the gut

56. **What are the effects of vegetarian type diets? What nutrients are difficult to get in a vegetarian diet?**
   a. Lack of protein, low caloric intake, incomplete AA
   b. Hampers health and performance if not executed correctly

57. **What body systems are affected by supplementation with Omega-3 rich fish oils?**
   a. Endocrine
      i. The exact mechanism(s) responsible for this phenomenon are not completely understood, but there are several possible explanations. For example, EPA and DHA are very effective at suppressing lipogenic gene expression [8,9], thereby limiting the synthesis of lipids. EPA and DHA have also been found to increase the oxidation of lipids as a result of an increase in carnitine acyltransferase I (CAT 1) activity [10,11], which allows greater fatty acid transport across the inner mitochondrial matrix via the carnitine-acylcarnitine translocase mechanism [12]. Additionally, EPA can increase mitochondrial lipid oxidation indirectly by inhibiting acetyl-CoA carboxylase [13], which is the enzyme that catalyzes the synthesis of malonyl CoA, and is a potent inhibitor of CAT I [14]. Moreover, EPA and DHA can also decrease the sensitivity of CAT I to malonyl CoA [11,15] which may allow a higher rate of lipid oxidation across a variety of different metabolic states. It is also possible that omega 3 fatty acids may influence total body lipid accretion by increasing thermogenesis as a result of increased activity of uncoupling proteins and peroxisomes [16],
and/or by increasing lean body mass [3,5], which would indirectly increase thermogenesis.

58. **Which common food has been shown to be an effective aid to post-exercise muscle recovery?**
   a. Low-fat milk

59. **Know the difference between labeling such as nutrition facts vs dietary facts**

60. **List the trace minerals**
   b. Zinc: cellular metabolism including catalytic, structural, and regulatory roles, Enzyme, cell membrane and protein Component in Copper-Zinc SOD (antioxidant)
   c. Manganese: It primarily works as a coenzyme that facilitates various metabolic processes in the body. The benefits of manganese in the body vary largely. It is involved in bone formation, thyroid function, formation of connective tissues, sex hormone function, calcium absorption, blood sugar regulation, immune function and in fat and carbohydrate metabolism.
   d. Copper: Copper is required in the formation of hemoglobin, red blood cells as well as bones, while it helps with the formation of elastin as well as collagen - making it necessary for wound healing.
   e. Fluoride: Small amounts of fluoride help reduce tooth decay. Adding fluoride to tap water (called fluoridation) helps reduce cavities in children by more than half.
   f. Molybdenum: Several functions of molybdenum include the prevention of dental caries, iron metabolism, uric acid excretion and maintenance of normal sexual function in males. Essential for utilizing nitrogen in the air, molybdenum is a trace element responsible for several biochemical processes involving cellular structures of the body. Cellular respiration and the utilization of oxygen are dependent on molybdenum to function
normally. Harnessing free radicals and preventing DNA and RNA missteps in reproduction, as well as the maintenance of cell membrane
g. Iodine: an essential component of the thyroid hormones thyroxine (T4) and triiodothyronine (T3). Thyroid hormones regulate many important biochemical reactions, including protein synthesis and enzymatic activity, and are critical determinants of metabolic activity \[1,2\]. They are also required for proper skeletal and central nervous system development in fetuses and infants \[1\]
h. chromium: essential mineral. Chr III is in foods and involved in glucose metabolism by enhancing the function of insulin.
i. selenium: Selenium dependent enzymes are essential to normal function, glutathione peroxidase converts ROS (H2O2) into H2O.

61. **What are the functions of testosterone in men and women?**
   a. Testosterone, which is produced in the testes (and in small amounts in the ovaries), is sensitive to mechanical overload and levels increase in response to resistance training.
   b. Protein synthesis and obviates impact of catabolic hormones.
   c. Augments HG, IG-F and interacts with receptors on neurons an increase amount of neurotransmitters, increase cell body size, dendrite length, and enhance force production.
   d. It works in opposition to cortisol, challenging the catabolic effects of cortisol.

62. **List the fat-soluble and water-soluble vitamins**
   a. Fat-soluble
      i. Vitamin E, A, D, K
   b. Water-soluble
      i. Niacin, Thiamin, Riboflavin, Biotin, B6, B12, Vitamin C, Folate, Pantothenic Acid

63. **What serves as the major source of CHO energy during exercise**
   a. Glycogen

64. **Is caffeine banned by the IOC? Creatine? Whey?**
a. Caffeine: NO
b. Creatine: NO
c. Whey: NO

65. **How does an extremely high-protein/low-carbohydrate diet affect appetite?**
   a. Should suppress appetite due to satiety

66. **What does calcium do in the body**
   a. Provides crystalline structure to bones
   b. Most abundant mineral
   c. Required for normal cellular function
   d. Stimulate muscle contractions

67. **What is a byproduct of incomplete fat oxidation?**
   a. Ketones and Acylcarnitines

68. **What are the functions of cholesterol?**
   a. Formation of steroid hormones, vitamin D, bile saltes. Integral part of cell membranes and myelin,

69. **How does blood lactate change during exercise?**
   a. Depending on exercise intensity it increases until it reaches a saturation point

70. **What is protein’s role as a fuel source during exercise**
   a. Last resort through gluconeogenesis, unless free floating BCAA’s are available.

71. **What are the effects of high fructose consumption?**
   a. Increased caloric intake and body weight
   b. Can cause GI distress and diarrhea

72. **What are lipids and what are the comprised of? Their structure**
   a. Lipids: a class of compounds consisting of triaglycerols, sterols, and phospholipids. IE FAT
   b. Glycerols: a three carbon molecule (three carbon sugar, c,h,o) that when released from storage can be recycled in the liver for the creating of new blood glucose (gluconeogenesis)
   c. Fatty Acids: chains of carbon and hydrogen atoms (aliphatic chains)
73. **What are the differences in thermoregulation between men and women?**
   a. If body composition is the same, there is no significant difference

74. **What is L-Carnitine?**
   a. In living cells, it is required for the transport of fatty acids from the cytosol into the mitochondria during the breakdown of lipids (fats) for the generation of metabolic energy.
   b. The carnitines exert a substantial antioxidant action, thereby providing a protective effect against lipid peroxidation of phospholipid membranes and against oxidative stress induced at the myocardial and endothelial cell level.

75. **What is GPLC? What effects does it seem to have on exercise metabolism and performance?**
   a. glycine propionyl-l-carnitine
   b. Can enhance peak power production in resistance trained males with significantly less LAC accumulation.

76. **What are retinoids? List them**
   a. The retinoids are a class of chemical compounds that are related chemically to vitamin A.
   b. Retinoids are used in medicine, primarily due to the way they regulate epithelial cell growth. Retinoids have many important and diverse functions throughout the body including roles in vision, regulation of cell proliferation and differentiation, growth of bone tissue, immune function, and activation of tumor suppressor genes.
   c. Retinol, retinal, tretinoin (retinoic acid, Retin-A), isotretinoin, alitretinoin, etretinate, acitretin, tazarotene, bexarotene, adapalene.

77. **Know the various reactions involving CK, C phosphorylase, ATP Kinase, and ATP phosphorylase.**
   a. CK: ADP+ CP → ATP (CK Enzyme dependent)
   b. ATP Kinase: ADP + ADP → ATP + P (ATP Kinase dependent)
   c. Creatine Phosphorylase: C+P → CP (C phosphorylase dependent)
   d. ATP phosphorylase: ADP+P → ATP (ATP P dependent)
78. **What is the effect of CHO consumption before vs. during exercise**
   a. Improves performance

79. **What is phosphatidylserine and what are its purported ergogenic effects?**
   a. PS is a major phospholipid of all cell membranes
      i. Synthesized directly on the mitochondrial-associate membrane
      ii. Effective liposomal delivery medium for improving the absorption of GABA.
      iii. Improves glucose concentration in the brain, Na, K, ATP, and Ach from brain
      v. Anti-catabolic, increased mental, increased recovery

80. **What is IGF-1 and where is it produced?**
   a. Insulin-like growth Factor 1
   b. Secreted by liver
   c. Protein synthesis

81. **Know the correlation between high/low fat diet and testosterone**
   a. Resting testosterone concentrations are positively correlated with fatty acids, monounsaturated FA, and percent of energy from fat.

82. **Which vitamin is lacking in a Vegan diet?**
   a. The active form of vitamin B12

83. **Know the contractile and cytoskeletal proteins in muscles**
   a. Contractile proteins: Myosin, Actin, Troponin, Tropomyosin
   b. Cytoskeletal: Alpha actinin, Titin, Nebulin.

84. **Name the branched chain amino acids**
   a. Leucine, Isoleucine, Valine

85. **What is the most common side effect of Creatine as reported in Scientific Literature?**
   a. While the only clinically significant side effect reported in the research literature is that of weight gain \([4,18,22]\), many anecdotal claims of side effects including dehydration, cramping, kidney and liver damage,
musculoskeletal injury, gastrointestinal distress, and anterior (leg) compartment syndrome still exist in the media and popular literature

86. What is the RDA for protein? in G/kg (g/lb) per day
   a. Sedentary .8 (.4)
   b. Rec exerciser 1.0-1.4 (.5-.7)
   c. Resistance trained maintenance 1.2-1.4 (.6-.7)
   d. Resistance trained gain mass 1.4-1.8 (.7-.9)
   e. Endurance-trained 1.2-1.4 (.6-.7)
   f. HIIT 1.2-1.8 (.6-.9)
   g. Weight-restricted sports 1.4-2 (.7-1)

87. What is the effect of frequent feeding (i.e. 6 meals a day) on appetite and metabolic rate.
   a. Increasing meal frequency does not appear to favorably change body composition in sedentary populations.
   b. If protein levels are adequate, increasing meal frequency during periods of hypoenergetic dieting may preserve lean body mass in athletic populations.
   c. Increased meal frequency appears to have a positive effect on various blood markers of health, particularly LDL cholesterol, total cholesterol, and insulin.
   d. Increased meal frequency does not appear to significantly enhance diet induced thermogenesis, total energy expenditure or resting metabolic rate.
   e. Increasing meal frequency appears to help decrease hunger and improve appetite control.

88. Know the rate of absorption of glucose and fructose
   a. The absorption capacity for fructose in monosaccharide form ranges from less than 5 g to 50 g and adapts with changes in dietary fructose intake. Studies show the greatest absorption rate occurs when glucose and fructose are administered in equal quantities. When fructose is ingested as part of the disaccharide sucrose, absorption capacity is much higher because fructose exists in a 1:1 ratio with glucose. It appears that the
GLUT5 transfer rate may be saturated at low levels, and absorption is increased through joint absorption with glucose.[25]

b. One proposed mechanism for this phenomenon is a glucose-dependent cotransport of fructose. In addition, fructose transfer activity increases with dietary fructose intake. The presence of fructose in the lumen causes increased mRNA transcription of GLUT5, leading to increased transport proteins. High-fructose diets[vague] have been shown to increase abundance of transport proteins within three days of intake.[26]

89. **What solution helps to stimulate oral receptors thus increasing excitability of the corticomotor pathway.**
   a. Carbohydrate-Electrolyte Solution

90. **What is the Female Triad**
   a. A syndrome in which eating disorders, amenorrhea, and decreased bone mineral density are present

91. **What are the most commonly found electrolytes in the body?**
   a. Calcium, Sodium, Potassium, bicarbonate, chloride, and phosphates.

92. **What are the energy-generating capacities of the body’s three main energy systems?**
   a. Phosphagen: Short, powerful small in amount
   b. Glyolytic: Medium,
   c. Oxidative: low intensity but virtually endless

93. **How can an athlete increase their muscle protein synthesis after they perform resistance training.**
   a. Ingestion of high GI CHO and protein (high quality, BCAA). Then more complex CHO

94. **Know examples of mono, di, and polysaccharides**
   a. Mono- Glucose, Fructose, Galactose
   b. Di- Sucrose, Lactose
   c. Poly- Starch

95. **What is a major gluconeogenic amino acid?**
   a. Glutamine and Alanine
96. **Know sports that use lactic acid energy system as primary energy system**
   a. Medium distance sprints
   b. Some football

97. **What is the function of cholesterol**
   a. Formation of steroid hormones, vitamin D, bile salts. Integral part of cell membranes and myelin,
   b. LDL - Low-density lipoproteins (LDL) carry cholesterol, triglycerides and phospholipids throughout the body so the cells can take what they need. Cholesterol becomes incorporated in cell membranes to strengthen them or help make hormones. Triglycerides provide energy. Phospholipids serve as emulsifiers, helping fat-soluble vitamins and hormones move in and out of the cells.
   c. HDL- high density lipoproteins, transport molecules that carry that stuff back to the liver for recycling
   d. VLDL - very low density lipoproteins

98. **Where does glycolysis occur? The Krebs Cycle?**
   a. Glycolysis: cytoplasm
   b. Krebs Cycles: matrix of the mitochondria

99. **Why is CHO considered the preferred fuel source during intense exercise**
   a. Quick, efficient, and is used in both anaerobic and aerobic

100. **What are the effects of caffeine on metabolism?**
    a. Well documented effects on thermogenesis and lipolysis
    b. Effects lipolysis by inhibiting a specific enzyme necessary to allow HSL to continue on its thermogenic pathway of breaking down triglycerides
    c. Stimulate energy expenditure vis a vis sympathetic and non sympathetic nervous system

101. **Know the effects of creatine supplementation**
    a. See Previous Answers

102. **Which amino acid, together with insulin, allows protein synthesis to be coordinated with dietary intake?**
    a. Leucine
103. **Which three sources supply the body’s primary need for water?**
   a. Exogenous water, fruits, vegetables, and meat

104. **What is the best post-workout meal if the goal is promoting skeletal muscle hypertrophy?**
   a. Protein and carb mix

105. **Know the following terms**
   a. Ergogenic Aid: increases energy
   b. Exergonic reaction: gives off energy
   c. Endergonic reaction: requires energy

106. **Factors that determine total daily energy expenditure**
   a. Age, Sex, Height, Weight, Physical Activity

107. **RDA, RDI, RDDI, ESADDI,**
   a. RDI: *Recommended Daily Intake* (RDI) is the daily intake level of a nutrient that is considered to be sufficient to meet the requirements of 97–98% of healthy individuals in every demographic in the United States.
   b. RDA: The RDA represents the establishment of a nutritional norm for planning and assessing dietary intake, and are the levels of intake of essential nutrients considered to be adequate to meet the known needs of practically all healthy people.
   c. RDDI: Rich Diet Digestive Inconsistency
   d. Estimated Safe and Adequate Daily Dietary Intakes (ESADDI), now renamed Adequate Intake (AI), for eight nutrients considered necessary for good health, even though nobody really knows exactly how much your body needs.

108. **Which compound has been shown to increase fat loss independently of anything.**
   a. Ephedra

109. **What is the recommended intake of water prior to exercising in heat?**
   a. 32-48 oz

110. **What are the effects of CHO consumption during exercise**
   a. Erogenic, increase performance and time to exhaustion
111. What minerals may be depleted as a result of sweating
   a. Sodium, chloride, potassium, magnesium.

112. What is the rate-limiting enzyme in glycolysis
   a. Phosphofructokinase

113. Know the effects of excessive sweating during exercise
   a. Dehydration, loss of electrolytes, hyperthermia, death

114. Know the effects of caffeine supplementation
   a. Increase in fat oxidation, sparing muscle glycogen
   b. Alters perceived effort
   c. Increases hormone-like beta endorphin
      i. Affect mood, reduce pain perception, create sense of well being
   d. Blocks adenosine and other NT, delaying fatigue

115. What influences the amount of water lost during exercise
   a. Types of foods ingested
   b. Exercise intensity
   c. Ambient temperature
   d. Individual sweat rates
   e. Age

116. What is the main fuel source during light to moderate exercise
   a. Fat Oxidation

117. Vitamin Megadose and relation to RDA
   a. In order for vitamin dosage to qualify as a megadose, it usually must vastly exceed the recommended RDA. Many vitamin megadoses pack in several months' worth of a certain vitamin into a single dose. This dose usually comes in the form of a single pill or injection that is prescribed by a doctor.

118. What are the effects of a decrease in intramuscular pH secondary to intense anaerobic exercise? What is the primary fate of lactate?
   a. The primary fate (~75%) of the lactate in recovery is CO₂ (the major product of oxidative metabolism) along with a variety of other end points including liver glycogen, amino acids, and other metabolic intermediates.
Their findings also suggest that lactate is the primary fuel source that pays for the oxygen debt rather than being the cause of the oxygen debt.

b. Reduces performance

119. What is plasma homocysteine levels a marker of?
   a. Elevated levels of homocysteine have been associated with a number of disease states.
      i. Dementia, Alzheimers, inflammation and CV disease.

120. What are the effects of Vitamin D on CV health?
   a. Vitamin D has also been shown to affect endothelial function, and decrease vascular calcification.
   b. Lower SBP, Increased Insulin Sensitivity
   c. Lower VLDL and TG’s
   d. Moderate inflammatory Cytokines

121. What are anabolic hormones in regards to skeletal muscle
   a. Androgenic, promote growth and protein synthesis

122. Polymerized vs concentrated glucose solution effects
   a. Absorption rates differ, polymerized are much slower

123. How are AA used for energy? Under what conditions are intramuscular AA degraded for energy
   a. splitting amino group from the carbon skeleton, with the amino group either disposed of through the urea cycle, or used for nucleotide synthesis, added to pyruvate to form Alanine. “Gluconeogenesis” and carbon skeleton converted to metabolites feeding catabolic energy producing pathways - glycolysis and Krebs cycle.
   b. Low glucose conditions

124. What are the effects of glycogen storage on body mass? How much water is stored with glycogen, gram for gram?
   a. 1 gram glycogen, 3 grams water

125. What is considered dehydration as it relates to % change in body weight?
   a. Minimal= 1-2% decrease

126. What are the metabolic effects of vanadyl sulfate?
a. Preported insulin sensitivity, no real anabolic effect.

127. The body is unable to oxidize the nitrogen component of which marcomolecule?
   a. Protein

128. How does low-glycemic carbohydrate intake affect the body during exercise
   a. Lower increase in instant performance, if high in fiber there may be gastric distress

129. Know approximate GI for various CHO sources.
130. Understand oxidative stress and free radicals
   a. Oxidation: LOSE ELECTRONS OR HYDROGEN, Gain Oxygen
131. What are the contributors to the anti-oxidant capacity of blood?
   a. variety of enzymatic (superoxide dismutase, catalase, glutathione peroxidase etc.) and nonenzymatic (carotenoids, tocopherols, ascorbate, bioflavonoids, bilirubin, uric acid etc)
132. What supplementation improves buffering capacity of skeletal muscle
   a. Carnosine and GPLC
133. Know trace minerals and general functions (Covered in the next section)
134. Know the ergoneic effects of creatine
   a. Increases capacity of the phosphagen system
135. What is HMB? Effects on LBM?
   a. hydroxyl-methylbutyrate (HBM)
   b. Evidence from cachectic cancer studies suggests that HMB may inhibit the ubiquitin-proteasome proteolytic pathway responsible for the specific degradation of intracellular proteins. HMB may also directly stimulate protein synthesis, through an mTOR dependent mechanism.
   c. A number of studies have indicated that HMB supplementation may elicit several ergogenic benefits, including anti-catabolic [17], anabolic [18], and lipolytic effects [19], among others [20]. Thus, it has been suggested that HMB may partly be responsible for the benefits of leucine supplementation.
136. **The intake of which vitamins, below RDA can result in physical performance impairment?**
   a. Iron

137. **What are the effects of pre-exercise bicarbonate loading?**
   a. Can help buffer lactic acid

138. **The % daily value is calculated based on what kcal diet?**
   a. 2000 kcal diet

139. **What are the effects of losing weight through diet only?**
   a. No change in lean mass, RMR may not change

140. **What is complete cessation of the menstrual cycle called?**
   a. Amenorrhea

141. **Understand the benefits in the timing for essential acid ingestion as it relates to exercise**
   a. Pre- can help prevent muscle breakdown for gluconeogenesis, and prep for post workout recovery
   b. Post- increase protein synthesis

142. **Know the general roles for calcium, potassium, sodium**
   a. Calcium
      i. In bone matrix
      ii. Cell signaling, muscle contraction
   b. Sodium and potassium
      i. Water regulation, ionic gradients, cell function

143. **Which vitamins play a role in body’s metabolism**
   a. Riboflavin
   b. Pantothenic Acid
   c. B6
   d. Biotin
   e. B12
   f. Vitamin C
   g. Chromium
   h. Magnesium
144. **What effect does elevated blood glucose have on beta cells of the pancreas?**
   a. Chronic exposure to hyperglycemia can lead to cellular dysfunction that may become irreversible over time, a process that is termed glucose toxicity. Our perspective about glucose toxicity as it pertains to the pancreatic β-cell is that the characteristic decreases in insulin synthesis and secretion are caused by decreased insulin gene expression.

145. **What serves as the predominant energy source for the body as the exercise intensity increases and in which part of the body is it stored?**
   a. Glycogen
   b. Muscles and liver

146. **What are ketones? How are they produced?**
   a. B-Hydroxybutyrate, and Acetoacetate (fuel sources derived from fat, different option than glucose)
   b. TAG lipolysis increased delivery of fatty acids to the liver leads to accumulation of substantial amounts of aceteyl-Coenzyme A and formation of ketone bodies in the mitochondrial matrix of the liver.

147. **Know RER's for carbohydrate, protein, and fat.**
   a. RER: respiratory exchange ratio (VCO2/VO2)
      i. 70% calorie usage at rest (fat) RER=.7
      ii. Carbohydrate is close to 1
      iii. Increase in RER at rested fed state
         1. Net fat synthesis due to CHO intake
            a. Oxygen liberation from oxygen rich glucose during degradation and formation of Fat (lipogenesis)
         2. Production of CO2 from glycolysis
   b. Protein= ~.8

148. **Know the functions of glutamine**
   a. Most abundant conditional A.A. (Anti-catabolic)
      i. Vital metabolic fuel
   b. Enhancement of protein and glycogen synthesis
c. Optimized cell hydration

d. Reduces markers of overtraining

e. Nitrogen shuttle in muscle tissue

f. Component of cerebrospinal fluid

g. Energy substrate for immune cells

h. 5-10g supplementation after exercise

149. **Placebo controlled vs Double Blind**

a. Placebo-controlled study: is a way of testing a medical therapy in which, in addition to a group of subjects that receives the treatment to be evaluated, a separate control group receives a sham "placebo" treatment which is specifically designed to have no real effect. Placebos are most commonly used in blinded trials, where subjects do not know whether they are receiving real or placebo treatment.

b. Double Blind: neither the individuals nor the researchers know who belongs to the control group and who belongs to the experimental group. Only after all the data have been recorded (and in some cases, analysed) do the researchers learn which individuals are which.

150. **What are the effects of supplementation with oat bran on muscle glycogen?**

a. Study was conducted in a Rat based model

b. The animals were divided into 3 groups: sedentary control group (C), an exercise group that received a control chow (EX) and an exercise group that received a chow supplemented with oat bran (EX-O).

c. **Time to exhaustion of the EX-O group was 20% higher** (515 ± 3 minutes) when compared with EX group (425 ± 3 minutes) (p = 0.034).

For hepatic glycogen, the EX-O group had a 67% higher concentrations when compared with EX (p = 0.022). In the soleus muscle, EX-O group presented a 59.4% higher glycogen concentrations when compared with EX group (p = 0.021). **TNF-α was decreased, IL-6, IL-10 and corticosterone increased after exercise**, and EX-O presented lower levels of IL-6, IL-10 and corticosterone levels in
comparison with EX group. It was concluded that the chow rich in oat bran increase muscle and hepatic glycogen concentrations. The higher glycogen storage may improve endurance performance during training and competitions, and a lower post-exercise inflammatory response can accelerate recovery.

151. **What are the functions of cholesterol?**
   a. Cholesterol is required to build and maintain membranes; it modulates membrane fluidity over the range of physiological temperatures
   b. Repairs cells
   c. Brain function
   d. Manufacture of vitamin D
   e. Hormone synthesis and bile production
   f. Antioxidant
      i. HDL cholesterol is a powerful antioxidant. It scavenges free radicals and prevent oxidative damage in the system. Thus, reduces the incidence of metabolic syndrome.

152. **What are the functions of alpha-hydroxy-isocaproic acid?**
   a. Alpha-Hydroxy-isocaproic acid (HICA) is an end product of leucine metabolism in human tissues such as muscle and connective tissue. According to the clinical and experimental studies, HICA can be considered as an anti-catabolic substance. The present study investigated the effects of HICA supplementation on body composition, delayed onset of muscle soreness (DOMS) and physical performance of athletes during a training period.
   b. Evidence of a direct in vitro inhibitory effect of HICA on various matrix metalloproteinase enzymes, which are responsible for degradation of various connective and protein tissues.
   c. 4-week HICA supplementation of 1.5 g a day leads to small increases in muscle mass during an intensive training period in soccer athletes.

153. **Know the dietary sources of unsaturated and saturated fatty acids**
   a. Unsaturated: Plant and Animal
b. Saturated: Animal

154. **What is the female Triad?**
   a. A syndrome in which eating disorders, amenorrhea, and decreased bone mineral density are present

155. **Differentiate amylose, amylopectin, cellulose, hemicellulose (all polysaccharides)**
   a. Amylose: Starch from plants, linear polymer chain
   b. Amylopectin: starch from plants; highly branched polymer chain
   c. Cellulose: non-starch polysaccharide, crystalline, strong, and resistant to hydrolysis.
   d. Hemicellulose: random, amorphous with little strength. It is easily hydrolyzed by dilute acid or base as well as myriad hemicellulase enzymes.

156. **What prepares fatty acids to enter the kreb cycle?**
   a. Carnitine transports FA to the mitochondria
      i. Beta-Oxidation, Acetyl CoA

157. **What population sees the greatest effect from beta-hydroxy-beta-methylbutyrate (HBMB)?**
   a. Various studies analyzed in this manuscript support the efficacy of HMB as an effective ergogenic aid for athletes that decreases DOMS, markers of muscle damage, and body fat, while increasing various markers of performance, including LBM and strength in resistance trained athletes, and OBLA and VO2 peak in endurance trained athletes, a number of studies analyzed did not support the efficacy of HMB supplementation

158. **Which skeletal muscle protein determines the contractility?**
   a. Myosin

159. **What are the effects of caffeine?**
   a. See 53, 101, and 116

160. **How much protein should athletes consume after an intense training regimen?**
   a. ~28 (according to the book but in truth it varies quite a lot)
161. **Supplementation with glutamine and phosphatidylserine is use to counteract the effects of which catabolic hormone?**
   a. Cortisol

162. **Increased insulin sensitivity and improved glucose metabolism are benefits of what supplement?**
   a. Chromium

163. **What is the primary active ingredient of Bitter Orange or Cirtus Auranitum?**
   a. Acts primarily on B-3 receptors, which are responsible for lipolytic and thermogenic effects
   b. Synephrine and octopamine

164. **What is the required dose for beta-alanine for ergogenic effects**
   b. 3.2-6.4 g/day 60 min before exercise on an empty stomach.

165. **Which buffer is responsible for regulating the acid-base balance in the kidneys and intracellular fluids?**
   a. Bicarbonate

166. **What happens during the first few weeks of resistance training, when accompanied by creatine supplementation?**
   a. Increased muscle mass, sprint performance, glycogen synthesis, increased work capacity, enhanced recovery

167. **What type of fatty acid contains two or more double bonds along the carbon chain?**
   a. Polyunsaturated fats

168. **What are the effects of protein together with exercise?**
   a. Addition of protein can have added benefits by reducing muscle degradation and speeding recovery, will enhance insulin response.

169. **What are the effects of quercetin on exercise?**
   a. on average, quercetin provides a statistically significant benefit in human endurance exercise capacity (VO2max and endurance exercise performance), but the effect is between trivial and small.
b. Both animal and human data suggest quercetin stimulates mitochondrial biogenesis. The scientific literature provides compelling clinical information about this interesting flavonol.

170. **What is EGCG?**

a. **Epigallocatechin gallate** (EGCG), also known as epigallocatechin-3-gallate, is the ester of epigallocatechin and gallic acid, and is a type of catechin.

b. EGCG is the most abundant catechin in tea and is a potent antioxidant that may have therapeutic applications in the treatment of many disorders.

171. **What are cellular mechanisms governing the ergogenic benefits of beta-alanine, creatine, caffeine, and protein (vis a vis nutrient timing)***

a. Beta-alanine: Beta-alanine is the rate-limiting enzyme in the synthesis of carnosine. In other words, the amount of carnosine your body produces is directly dependent on the amount of beta-alanine available. Without sufficient beta-alanine, carnosine synthesis is limited.

   i. Supplementation with beta-alanine appears to have the ability to augment performance and stimulate lean mass accrual in a short amount of time (8 weeks) in previously trained athletes. β-alanine may magnify the expected performance outcomes of training programs with different metabolic demands.

b. Creatine: increases Creatine stores in muscles, enhances ability of phosphagen system.

c. Caffeine: see 53, 101, 116

d. Protein: Addition of protein can have added benefits by reducing muscle degradation and speeding recovery, will enhance insulin response. Increased muscle protein synthesis post workout.

172. **What is the main energy system used for sprints less than 10 seconds?**

a. Phosphagen

173. **What is the primary fate of lactate upon cessation of intense exercise**

a. It is oxidized, converted to its salt, lactate, by buffering systems in the muscle and blood.
b. Lactate is used in gluconeogenesis, the formation of glucose from lactate and non-carbohydrate sources during extended exercise and recovery.

174. **What is the difference between motor unit recruitment and rate coding**

   a. Recruitment
      i. Henneman size principle

   b. Rate coding
      i. Frequency

175. **What is the main difference between whey protein concentrate, whey protein isolate, and whey protein hydrolysate?**

   a. Whey protein concentrate: contains some fat and lactose.
      i. Concentrate is less processed and more whole, but has less protein

   b. Whey protein isolate is pretty much pure protein with very little of the other dairy elements remaining. Isolate is about 90-94% protein, but it’s subjected to a more rigorous refinement process. Bodybuilders are drawn to the “purity” of whey isolate, lured by the moderately higher protein counts

   c. Whey hydrolysate is predigested whey protein that’s easily absorbed and virtually free of any potential allergens.

**Vitamins and Minerals**

**WATER SOLUBLE VITAMINS**

**Thiamin:** A B-complex vitamin known as vitamin B1. In the body, it can exist as free or phosphorylated thiamin (monophosphate, triphosphate, and pyrophosphate). Triphosphate is found in high concentrations in nerve and muscle cells and can activate ion channels allowing the flow of sodium and calcium. The coenzyme TPP is important in mitochondrial functions.
Theoretically, as thiamin is required for energy production in the Krebs cycle and pentose phosphate pathway, supplementation could increase aerobic performance. However, thiamin deficiency is not common and research has not proven that excess thiamin enhances performance.

**Riboflavin**: A B-complex vitamin known as vitamin B2. It is a primary component of the coenzymes FAD and flavin mononucleotide. Flavins are critical in the metabolism of all macronutrients and plays an antioxidant role. Hydrogen peroxide can be broken down by the antioxidant enzyme glutathione peroxidase in the presence of reduced glutathione.

The FAD dependent enzyme, xanthine oxidase, is used to produce uric acid, which at physiological concentrations, contributes to the total antioxidant capacity of the blood plasma more than any other compound including vitamins C and E.

There is no research to indicate Riboflavin as a performance enhancer.

**Niacin**: A B-complex vitamin known as vitamin B3. In the body it is utilized in the forms of nicotinic acid, nictinamide, NAD, and NADP. NAD and NADP are coenzymes required by roughly 200 enzymes, are exceptional electron donors, and are essential in the catabolism of all the macronutrients as well as the synthesis of fatty acids and cholesterol.

Although Niacin supplementation has been shown to reduce FFA and increase CHO oxidation, it has not been shown to increase performance.

**Pantothenic Acid**: A B-complex vitamin known as vitamin B5. The major contribution of PA to human metabolism is its role as a component of Coenzyme A. CoA is critical in generation of ATP from macronutrients, and the synthesis of essential fats, cholesterol, and acetylcholine. PA has been shown to decrease blood lactate and O2 consumption, but no improved aerobic performance.

**Vitamin B6**: B6 is found in the body as pyridoxal, pyridoxine, pyridoxamine, pyridoxal 5'-phosphate (PLP), pyridoxine 5'-phosphate, and pyridoxamine 5'-phosphate. PLP is the active coenzyme in the body and is vital to human metabolism. PLP is a coenzyme
for glycogen phosphorylase, which releases muscle glycogen for energy production in the form of glucose. PLP is active in gluconeogenesis, and in the production of serotonin, dopamine, norepinephrine, and GABA. B6 supplementation does not appear to improve aerobic performance.

**Folate:** A B-complex vitamin known as folic acid. It is a cofactor in the transfer of one-carbon units. Folate accepts and donates carbon, indicating its importance in nucleic acid and amino acid metabolism. No ergogenic effects of folate supplementation have been noted.

**Biotin:** A B-complex vitamin known as vitamin H. Biotin cannot be synthesized by the body and must be a part of our diet. Is a cofactor in the carboxylases and plays a role in FA synthesis, gluconeogenesis, leucine metabolism, and metabolism of various AA, cholesterol, and odd-chain FA.

**B12:** The largest and most complex of the B-complex vitamins. Like biotin, B-12 cannot be synthesized by the body. B12 contains cobalt and is AKA cobalamin. Methylcobalamin is required for methionine synthase activity which converts homocysteine to methionine. In well-nourished individuals, it is unlikely that B12 supplementation will enhance performance.

**Vitamin C:** AKA ascorbic acid, is an essential vitamin and must be obtained exogenously. Vitamin C is important in the synthesis of collagen, the production of carnitine, and acts as an antioxidant by scavenging cytotoxic free radicals and recycling the vitamin E radical back to its reduced state. Vitamin C supplementation has resulted in improvements in exercise-induced damage.

**FAT SOLUBLE VITAMINS**

**Vitamin E:** Vitamin E refers to a group of antioxidants including the tocopherols and tocotrienols. They both have an alpha, beta, gamma, and delta form, with alpha tocopherol being the most active form in the body. Vitamin E serves as a powerful antioxidant by scavenging peroxyl radicals and inhibiting liped peroxidation in cell membranes (oxidative damage)
Vitamin E may attenuate exercise-induced damage, however no evidence exists that indicates vitamin E supplementation improves performance.

**Vitamin A:** Vitamin A encompasses a group of compounds including the retinoids (retinol, retinal, and retinoic acid). Retinol can be produced from beta-carotene and other carotenoids, which are antioxidants that neutralize free radicals such as singlet oxygen and peroxyl radicals. Because vitamins A and C are more powerful antioxidants, supplementation is not warranted with respect to redox control.

**Vitamin D:** Vitamin D3 (cholecalciferol) is the primary for used in the body. Cholesterol can be converted into 7-dehydrocholesterol, a precursor to D3. UV light converts 7-dehydrocholesterol into VD3 in the skin. No performance enhancement has been observed with VD supplementation.

**Vitamin K:** K1 (phyllloquinone) and K2 (menaquinone-n). Coenzyme for Vitamin K dependent carboxylase, which is involved in the carboxylation of glutamic acid into GCA. Crucial for binding calcium to certain proteins.

### MINERALS

**Calcium:** Calcium is the most abundant mineral in the body and vital for normal cellular function. When deficient in the diet, the body will absorb calcium from bone stores to maintain proper calcium levels. It is essential in stimulating muscle contractions and should be supplemented in cases of osteoporosis.

**Chromium:** An essential mineral that comes in trivalent chromium (III) and hexavalent chromium (VI). Chromium III is the form available in food and utilized in the body. It is involved in glucose metabolism by enhancing insulin function. Supplementation has not shown increased strength and is not recommended.

**Iron:** Iron is involved in hundreds of proteins and enzymes in the body, such as hemoglobin and myoglobin. When free iron is in its ferrous state (FE+2), it reacts with H2O2 and superoxide to form the highly reactive hydroxyl radical (OH). Iron deficiency anemia is the most common and results in reduced oxygen transport capacity. Supplementation is recommended in those with iron deficiency.
**Magnesium:** Magnesium is involved in more than 300 essential metabolic reactions including metabolism of CHO, fats, proteins, and nucleic acid. The antioxidant glutathione requires magnesium for its synthesis. ATP is usually found in the body as MgATP. It also plays a structural role in bone cells, cell membranes and in chromosome. In addition, magnesium is required for the active transport of potassium and calcium across membranes which in turn can affect nerve conduction and muscle contraction.

**Zinc:** Upwards of 100 different enzymes are dependent upon zinc, and it plays an integral role in the structure of cell membranes and proteins. Zinc is a key component in the cytosolic antioxidant superoxide dismutase, thus, decreased zinc can lead to oxidative damage of the cell membrane. It is also involved in cell signaling, release hormones, aid in nerve conduction and participates in apoptosis.

**Phosphorous:** Phosphorous is ubiquitous throughout the body and is required for every cell to properly function. The majority of phosphorous found in the body is in the form of phosphate (PO4). It is a structural component of bone as calcium phosphate salt known as hydroxyapatite. It is also a component of ATP and CP.

**Selenium:** Selenoproteins include glutathione peroxidase and thioredoxin reductase. Glutathione peroxidase with glutathione can convert H2O2 into water. TR is involved in the regeneration of several antioxidant systems including ascorbate.
**Phosphagen System**

- CK reaction: CrP + ADP → ATP, Cr
- MK reaction: ADP + ADP → ATP, AMP*

**ANAEROBIC METABOLISM**

- *AMP Signals Gylcolysis

**Glycolysis**

- Glucose/Glycogen → Lactate, Pyruvate
- Pyruvate → O2 Absent, ATP
- O2 Present, ATP

**Cori Cycle**

- Lactate

**Kreb’s Cycle**

- Fatty Acids → Acetyl CoA → Amino Acids
- Acetyl CoA → NADH/FADH, ATP/GTP
- NADH/FADH → ETC (Electron Transport Chain)
- ETC → O2, H2O

**RED IS INPUT SUBSTRATE**

**BLUE IS OUTPUT SUBSTRATE**

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CISSN STUDY GUIDE