

Carbohydrate: Ultimate Food Fuel, Part IV

by John Parrillo



In carbohydrate metabolism, the rate of glycogen utilization is directly proportional to the intensity of the exercise (1). In other words, the faster the body needs to produce energy, the more it relies on carbohydrates. This is because fat cannot be metabolized fast enough to meet the energy demands of high exercise. Furthermore, carbohydrates can be metabolized to produce energy anaerobically (in the absence of oxygen) while fat metabolism requires oxygen. Also, during aerobic metabolism, it takes less oxygen to burn carbs than to burn fat. For a given amount of oxygen, the body can produce more ATP from carbs than from fat. This makes carbohydrate a better fuel source during intense exercise when oxygen is a limiting factor.

The respiratory quotient (RQ) is the ratio of carbon dioxide produced to oxygen consumed. One liter of oxygen is able to produce 5 calories from carbohydrates but only 4.7 calories from fat (2,3).

Since carbohydrates and fat require different amounts of oxygen to burn, you can tell from the respiratory quotient what kind of fuel is being used by the body. An RQ of 1.0 indicates carbs are being used exclusively for energy (4).

Intermediate values of RQ indicate that a mixture of both fuels is being used. Using this sort of measurement during cycling exercise, research found that carbohydrate, when available, is the body's preferred fuel. Radioisotope studies and muscle biopsy assessments of energy stores before and after exercise have confirmed this finding (4).

In general, as intensity of exercise increases, the relative contribution of carbohydrate as the fuel source increases (1,2). Furthermore, a low-carbohydrate diet reduces exercise time to exhaustion (1). At rest, muscles rely mostly on fat as their energy source (5).

During low intensity exercise (40-50% VO₂max) such as walking, the primary metabolic fuel is fat, while muscle glycogen degradation is minimal (1). As the exercise intensity increases, more muscle glycogen is used as fuel. Moderate intensity exercise (50-60% VO₂max) is fueled by roughly equal amounts of fats and carbohydrates (2, 4). At 90-95% VO₂max, carbohydrate provides as much as 95% of the energy and the RQ approaches 1.0 (1, 2, 4). Many athletes train at intensities above 70% VO₂max which precludes the use of fat as fuel.

Although high-intensity exercise burns more calories per hour, more of those calories come from carbs. Low-intensity exercise is fueled mostly by fat, but doesn't burn very many calories per hour. One of the best exercises for losing

fat is running. Although running is high intensity and is fueled partially by carbs, it has the additional benefit of lowering your set point — the amount of fat your body is programmed to store.

When glycogen stores are limiting, the body also draws on amino acids as fuel (4, 5). The liver can convert most amino acids into glucose in a process called "gluconeogenesis." The branched chain amino acids (BCAAs) leucine, isoleucine and valine can be oxidized as fuel directly in the muscles (5). One study showed that as much as 57 grams of protein — equivalent to the recommended daily allowance — could be burned as fuel during a 10-12 mile run (6). Lemon and Mullen showed that during a cycling effort lasting over an hour at 61% VO₂max, 10.4% of the energy was derived from protein if the subjects were in a glycogen-depleted state (7). In a glycogen-loaded state, only 4.4% of energy derived was from protein. This is another important reason why body-

During aerobic metabolism, it takes less oxygen to burn carbs than fat. This makes carbohydrate a better fuel source during intense exercise when oxygen is a limiting factor.

builders need to ensure adequate carbohydrate intake: Carbs have a protein-sparing effect, meaning that if adequate carbs are available, they will be used instead of protein. Obviously, bodybuilders want their amino acids to be used for building protein, not as fuel.

Pro-Carb is the ultimate carbohydrate supplement. Carbohydrates are a great energy source for fueling athletic activities and supporting weight gain. Pro-Carb is ideal for carb loading, for use during training and athletic competition and as a source of extra calories. Not only is it high in carbohydrates, but a Pro-Carb drink also supplies water which is needed for glycogen storage. Liquid carbohydrate meals can be consumed closer to competition than solid foods because of their shorter gastric emptying time (2). Liquid meals also produce a low stool residue and thus minimize intestinal bulk. Liquid meals are a good way to get calories in without filling up your intestines. Pro-Carb is also an excellent supplement to add extra calories during heavy training. Pro-Carb utilizes maltodextrin as its carbohydrate source. Maltodextrin is a complex carbohydrate derived from starch with a low glycemic index (ranging from 22 to 29), meaning that it is released into the bloodstream more slowly than simple sugars (glucose has a glycemic index of 100). That way, you don't get a large insulin surge with subsequent

hypoglycemia. Using Pro-Carb, you get a more even energy level because the carbs are released slowly, minimizing the chance that any will "spill over" into fat stores. Maltodextrin is a glucose polymer, making it ideal for replenishing glycogen stores. Pro-Carb mixes instantly and tastes great, and contains no simple sugars or artificial sweeteners. One scoop provides 22 grams of complex carbs, 4 grams of high quality protein, with less than a gram of fat. Mixed with out Hi-Protein powder, it makes a balanced liquid meal.

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Supplementation For Ultimate Endurance Performance

by John Parrillo



Parrillo Performance provides the best quality supplements in the world. Period. We don't cut any corners when it comes to nutritional support for our athletes. We want you to get the most from your training, and we want you to reach your goals. We're here to help you win. In addition to our famous success with bodybuilders, we also work with world class endurance athletes. In this article I will describe some of our best supplements for endurance athletes, why they work and how to use them. Even if you're not an endurance athlete and are just looking for more energy, our approach to diet and supplementation is sure to help. Finally, it's also worth mentioning that many of the best bodybuilders also rely on our endurance supplements when they want to train longer and harder, and, more importantly, recover faster and more completely.

Ultra-endurance activities are associated with loss of lean body mass (1,2). Endurance activity causes loss of lean tissue because as fat and carbohydrate fuels are exhausted the body draws on its own muscle tissue to use as fuel (3). Amino acids can be converted to glucose in the liver via a process known as "gluconeogenesis" (4,5). The

so-called "branched chain amino acids" (leucine, isoleucine and valine) seem to be especially preferred as fuel substrates. In addition to being converted to glucose in the liver, the amino acids are unique in that they can also be used directly as fuel by the muscles (5). These are the amino acids included in our product "Muscle Amino." Muscle Amino contains the balance of branched chain amino acids science has shown most beneficial.

Have you ever noticed an ammonia smell in your clothes after a hard workout? This is because your body was using some amino acids as fuel but was not able to clear the waste products efficiently. When this happens the carbon skeleton of amino acids is burned, leaving ammonia as a byproduct. Ammonia is quite toxic and is converted to urea in a metabolic pathway called "the urea cycle," which prepares it to be excreted in the urine (4,5). The urea cycle requires certain chemical compounds called "aspartates," (4,5) which are included in our "Max Endurance Formula." We have developed this product specifically for use during endurance activities. It works by providing nutrients which are used by the body to detoxify the waste products of protein catabolism. Max Endurance helps filter out toxic waste products your body generates during intense training. Eliminating these waste products helps you have more energy and recover faster. Ammonia is very toxic and will stop energy production in the cell. Using the aspartates in Max Endurance to "neutralize" the ammonia as soon as it forms enables you to have more energy and endurance. We suggest the product be used consistently everyday, not just on days of endurance events.

Perhaps the most crucial supplement for

endurance athletes is our "Liver-Amino Formula." I cannot overemphasize the importance of this product. What is endurance activity all about, anyway? It's about producing energy over an extended period of time. Liver-Amino helps in at least three ways — by providing heme iron, protein and B vitamins.

Energy production in the human body requires two things: a fuel substrate and oxygen (3,5). Many people build up the importance of carbohydrates in endurance performance — and rightfully so. Carbs are your body's best fuel source for endurance activity (3,6,7). However, for those carbs to be used as fuel your muscles require a constant supply of oxygen. Contrary to popular belief, it is usually the rate of oxygen delivery to cells which limits energy production, not the availability of glucose.

As you know, it is the responsibility of red blood cells to deliver oxygen to all the working tissues of your body (4). What you may not know is that endurance training actually can destroy red blood cells rather than building them up — if your nutrition's not right. Bodybuilders have long recognized that strength training actually breaks down muscles and that this damage provides the stimulus for subsequent growth during the recovery period. To build more muscle, you have to provide the nutrients muscles are made of. The same is true for endurance training, except it's the blood system that takes a beating. And if you want to recover and be stronger as a result of your workout, you have to feed your body with the nutrients it needs to make red blood cells. Have you ever noticed that many endurance athletes are very thin and don't have much muscle mass? Why is that? To understand why this happens, and what to do about it, you need to know a little about physiology and how the body adapts to endurance training.

Endurance activity causes a condition referred to as "sports anemia" (8-11). This occurs rapidly with the onset of training

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(9,11). Endurance training causes an increase in mitochondrial content of the muscle tissue (mitochondria are the furnaces inside the cell where fuels are burned — the more energy you produce the more mitochondria you need), in myoglobin concentration (a protein like hemoglobin, which is involved in transporting oxygen inside muscle cells), and in cytochrome enzymes (enzymes of the electron transport chain, involved in aerobic energy production) (12). All of these are protein structures which are increased as an adaptive response to endurance training. To achieve this increase, the body draws on its erythrocytes (red blood cells), hemoglobin and plasma proteins as a source of protein (10-12). This is an example of the “plasticity” of the body — the body remodeling its own structures to adapt to changing conditions. In other words, what’s happening is the body needs to build up its energy producing systems inside muscle cells to adapt to the training stimulus. These energy pro-

ducing systems are made of protein. And the easiest place for your muscle cells to find protein is to steal it from red blood cells and plasma protein.

Couple this increased protein need with the fact that endurance activity causes amino acids to be used as fuel substrates instead of as proteins, and you can see why endurance athletes are frequently borderline anemic and why they commonly experience muscle wasting.

Liver-Amino contains heme iron — the most bioavailable iron source (8). (Refer to our article about Liver-Amino for more information.) The product contains desiccated liver (not cooked), as cooking can destroy the heme group and decrease its incorporation in red blood cells by 50% (8). Liver-Amino formula also provides 1.5 grams of complete protein per tablet. Heme iron and protein are precisely the nutrients your body needs to produce red blood cells. This way you can build your energy producing systems inside muscle cells and your blood system all at the same time, without having to sacrifice one for the other. Plus it’s a rich source of B vitamins, which are used in energy production. Start taking the Liver-Amino (five to eight with each meal) when you’re training hard and definitely at least six weeks before your event, since it takes that long to build up red blood cells.

Next month we’ll examine several supplements that can be used in an endurance program for ultimate performance.

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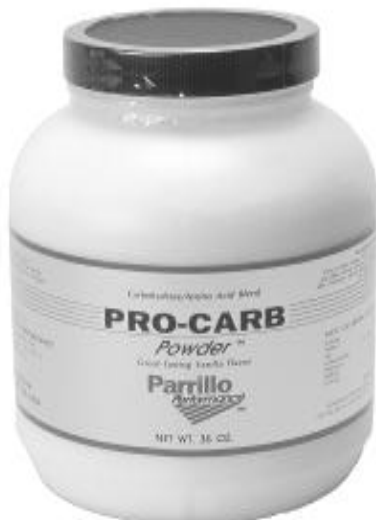
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Supplementation For Ultimate Endurance Performance, Part II

by John Parrillo

Endurance athletes experience increased need for protein (1-4). Most people are surprised to learn that studies actually show endurance athletes have even higher protein requirements than most strength athletes (1,2). This is due to the fact that the amino acids (the building blocks of protein) are used as fuel during endurance training (1,5). I suggest that you consume at least one gram of complete protein per pound of bodyweight—1.5 grams would be even better—from chicken, fish, turkey or egg whites each day with at least another .25 or .5 gram of additional protein per pound of bodyweight coming from incomplete vegetable sources. This leads directly to our “Hi-Protein Powder.” Calorie for calorie, this protein powder is the highest quality protein food available anywhere. It contains exactly the balance of amino acids your body needs to build proteins, including muscle, red blood cells and the energy producing systems mentioned.

Now we can turn our attention to fuel for optimum endurance performance. We have developed three high-energy supplements to help meet the needs of serious endurance athletes: Pro-Carb Powder,

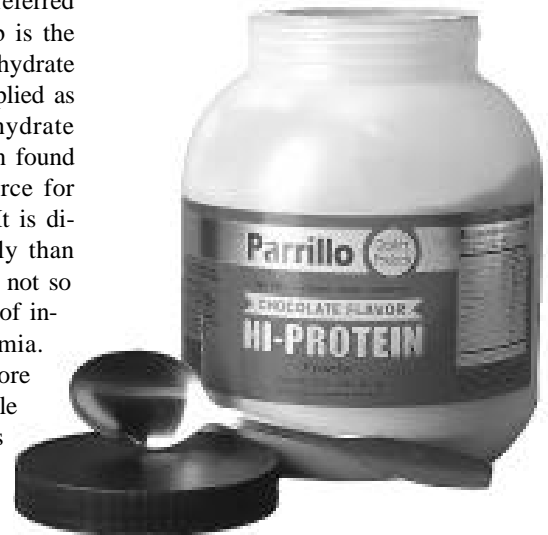


CapTri and the Parrillo Supplement Bar.

Carbohydrate is the body's preferred energy source (6,7) and Pro-Carb is the world's most sophisticated carbohydrate powder. The carbohydrate is supplied as maltodextrin, a complex carbohydrate from corn. Maltodextrin has been found to be the ideal carbohydrate source for replenishing glycogen reserves. It is digested and absorbed more rapidly than conventional carbs from food, but not so fast that it causes an over-release of insulin and subsequent hypoglycemia. Maltodextrin provides a much more uniform energy level than do simple sugars. Refer to our recent series about carbohydrates and athletic performance for more detailed information about Pro-Carb.

CapTri is a special kind of fat known as a medium chain triglyceride (8-10). CapTri provides twice the energy density of protein and carbohydrate (8.3 calories per gram for CapTri versus 4 calories per gram for carbs and protein) and is absorbed into the bloodstream as rapidly as glucose (8-10). CapTri is preferentially used as fuel for energy, instead of being stored as fat by the body (9). As an added benefit, CapTri has a thermogenic effect, which means that it is converted to energy very rapidly (9). CapTri is an extremely concentrated source of calories which are rapidly absorbed and metabolized for energy by the human body. We think of CapTri as human jet fuel. Start with 1/2 tablespoon at every meal. After a few days, increase to one tablespoon with each meal. During hard training, many athletes go as high as two or three tablespoons per meal—a level they have found to be beneficial. Continue to use CapTri up to and during your endurance competition. You cannot store the energy from CapTri, so you need to use it at each meal.

Another key point which many people



don't understand is that some of the energy from CapTri is converted in the liver to ketone bodies, which are used as fuel by the muscles (9,11). The efficiency of utilization of ketones as fuel substrates by peripheral tissues improves as the body adapts to CapTri. In other words, your body gets better at using CapTri as it gets used to it. Thus, using it consistently will allow you to get more out of it when you really need it. Also, these same ketone bodies produced by CapTri help prevent the use of amino acids as fuel (11). That way, your aminos get used as protein instead of being burned as energy. CapTri also decreases catabolism of skeletal muscle protein (9,11). This is why CapTri is effective in reducing the loss of lean body mass commonly experienced by endurance athletes.

The Parrillo Supplement Bar is the endurance athlete's dream. It is a combination of everything — protein, carbs and CapTri — in just the right ratio for optimum energy production. Energy-dense, ready to eat and great tasting. The Bar is very popular with cyclists and hikers and

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bodybuilders eat them between meals for extra calories.

To sum up, Parrillo Performance has developed a unique and powerful line of nutritional supplements for endurance athletes and anyone who wants more energy, strength and stamina. I suggest you start with the Liver-Amino Formula, since it provides protein and heme iron — the precise nutrients your body needs to build muscle, red blood cells and energy producing systems. Where to go from there is a highly individual matter. If you're not getting enough protein from conventional sources, the Hi-Protein Powder is probably the next thing to add. If you need more calories, go with Pro-Carb, CapTri or the Supplement Bar. The Supplement Bar is a nice choice because you get protein, carbs and CapTri all in one. If you're training on the edge and

want to explore the limits of your potential, add in Max Endurance Formula and Muscle Amino. Feel free to call or write and we'll help you work out your individualized program.

In general, I suggest you begin using endurance supplements when training hard and definitely for at least three to six weeks before your event to build up your nutrient level reserves. This is especially true for Liver-Amino, since it takes about six weeks to build red blood cells. We get better results if the nutrition and supplements regimen is followed daily, not just around competition time. Consistency and dedication make the difference between champions and recreational athletes, and that applies to nutrition and supplementation as well as to training.

P.S. Don't forget your Essential Vitamin Formula and Mineral-Electrolyte Formula, both of which can be doubled when in hard training.

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Muscularity & Mass: Optimize Your Hormonal Response Through Diet

by John Parrillo

If you've been reading my articles consistently over the last couple of years, by now you have a better understanding of biochemistry and sports nutrition. I've covered the metabolism of proteins, carbohydrates, fat and medium chain triglycerides in detail, explaining how to use each for maximum results. At Parrillo Performance, we never lose sight of the fact that results are the bottom line. What sets us apart is not just the superior quality of our products but also that we teach you how to get the best results. People who follow the Parrillo Program invariably get better results than they ever thought possible.

In this series, we're going to look a little deeper into how all the nutrients that we've discussed come together in the body to produce results. You know that getting ultimate results requires an intense training program and consistently perfect nutrition. But why does it work and how does it work? Obviously, all the energy used by your body and all the matter that makes up your body ultimately comes from food. For our purposes, it is convenient to consider the body as being divided into fat compartment and lean compartment. What determines whether the food you eat goes to the fat compartment, the lean compartment, or simply gets burned for energy? How can you control this? This is the subject of this series of articles.

The branch of science that explains how the body works and how it is controlled is called "physiology." This science merges beautifully with biochemistry to explain how you can control nutrient partitioning into the fat compartment or the lean compartment. So, let's talk a little bit about physiology.

The two master control systems of the body are the nervous system and the endocrine system (1,2). The nervous system consists of the brain, the spinal cord (the central nervous system) and the

nerves that transmit information to and from the all parts of the body (the peripheral nervous system). The nervous system works by transmitting information in the form of electrical signals (nerve impulses).

The endocrine system consists of several organs in the body, including the pituitary gland, the thyroid gland, the parathyroid glands, the pancreas, the adrenal glands, the testes or ovaries and the kidneys. The endocrine system transmits information in the form of chemical messages. (When parts of your body talk to each other using the nervous system, it's like making a phone call, and when they use the endocrine system, it's more like sending letters.) The chemical messages sent by the endocrine system are called "hormones." Testosterone, growth hormone and insulin are examples of hormones everyone knows about. These

hormones have a profound effect on whether the food you eat ends up as muscle or fat. Your diet and exercise habits, in turn, have a profound effect on these hormones. (Are you starting interested in physiology now?)

Hormones can be classified in several ways (1,2). One way is by their mode of release. the classical hormones, for example, are released into the bloodstream and are carried throughout the body. These are called "endocrine" or "telecrine" hormones. Other hormones are not released into the blood but rather into the space between tissues (the interstitial space) and thus exert their effect only on nearby tissues. These are called

"paracrine" hormones. Finally, some hormones exert their effect only on the cells that produce them and are called "autocrine" hormones. Hormones can also be classified according to their chemical structure. Examples include the steroid hormones (which are made of fat molecules resembling cholesterol), protein hormones, peptide hormones and amino acid derivatives. Testosterone is a steroid hormone while insulin and growth hormone are protein hormones.

The nervous system acts to control actions that require a fast response time: movement, perception of the world around you, rapid adjustment of heart rate and breathing rate in response to exercise and behavior in general. The endocrine system controls processes that occur over a longer period of time, such as fuel metabolism and growth (Making a phone call is faster than writing a letter.) Notably,

Hormones have a profound effect on whether the food you eat ends up as muscle or fat. Your diet and exercise habits, in turn, have a profound effect on these hormones.

the nervous system and the endocrine system do not function separately. They are tied together by a part of the brain called the hypothalamus. This is the main way the two systems communicate to each other to ensure coordinated control of the body. The hypothalamus is located on the bottom surface of the brain roughly in the middle, and the pituitary gland is connected to it. Together, the hypothalamus and the pituitary are considered to be the master endocrine gland of the body, controlling the function of all other endocrine glands.

The endocrine system is chiefly responsible for nutrient partitioning into the fat or lean compartments (1,2). This sys-

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tem deals with fuel metabolism, energy production, energy storage and growth. And this means control of growth of both muscle stores and fat stores. Therefore, the endocrine system will be the focus of our attention for the next few bulletins.

Remember, the endocrine system is the control system of metabolism and growth, and it issues its orders in the form of hormones. These hormones are released from the various endocrine glands and are carried to all the tissues of the body by the bloodstream. There they bind to special molecules on cells called "hormone receptors" that interpret the signal being sent by the hormone and tell the cell what to do. The transmissions sent by the hormones are messages like "build muscle protein," "store fat," "burn fat," "store carbohydrates," "burn carbohydrates," and so on.

Once these signals are received by the body, the biochemical work of obeying the command sent by the endocrine system is carried out by enzymes. Enzymes are special protein molecules that control the rates of chemical reactions going on inside cells. By these reactions, the enzymes can make or degrade proteins and fat. This is how your body composition is regulated. While some hormones work by controlling enzymes, other work by directly activating certain genes in the nucleus. Testosterone is an example of

such a hormone, which activates genes involved in protein synthesis.

The main hormones involved in muscle growth and fat loss are insulin, glucagon, testosterone, growth hormone and insulin-like growth factor (IGF). And guess what? We can teach you how to control all of them through diet and exercise. In addition to explaining the control of these hormones, we will also talk about prostaglandins, an important class of hormones involved in

regulation of blood pressure, blood clotting, inflammation, growth hormone release and many other processes (3). You can control your levels of prostaglandins through diet, and this in turn can also have a big effect on growth hormone release (4,5). We're also going to talk about the ways nutrients directly effect enzymes inside cells to influence the rate of fat storage and fat loss.

The first thing to do is to take your Parrillo Performance Nutrition Program off the shelf and take another look at it. That diet didn't fall together by accident. You will see that it was developed with all of this knowledge of biochemistry and physiology in mind. And it works. Over many years of working with the top bodybuilders we found that this approach simply works the best. As you will see in the next bulletin, one of the most important factors in determining nutrient partitioning is your ratio of insulin to glucagon (6). The ratio of these two hormones produced by the pancreas largely determines whether you will gain fat or lose fat. This ratio also starts a cascade of events which regulates the balance of prostaglandins your body produces, which in turn has a big effect on growth hormone release. And growth hormone has a profound effect on muscle growth and fat loss. It all flows together.

Your body's ratio of insulin to glucagon is determined solely by the ratio of

protein to carbohydrate in your diet. Generally, you want to consume about 1.5 times as many calories from carbohydrate as protein (7). When you're trying to gain weight, you want a little more insulin so you eat a little more carbohydrate. When you're trying to lose fat you want to decrease insulin levels and increase glucagon. To do this you adjust your ratio of carbs to protein down a little. You'll see this is exactly how our Nutrition Program and Pre-Contest Diets are set up.

The Parrillo System was designed to help your body work naturally at peak efficiency to become a muscle-building, fat-burning machine. You want results? Follow the Program.

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The Insulin-Glucagon Axis and the Control of Nutrient Partitioning

by John Parrillo

In Part I of this series we began our discussion of endocrine physiology. I explained that hormones play a central role in nutrient partitioning. But what is nutrient partitioning? This is the process of determining whether the food you eat ends up as muscle or fat or just gets burned for energy. The hormones chiefly responsible for this are insulin, glucagon, growth hormone, thyroid hormone, cortisol and epinephrine (adrenaline). In addition, testosterone, aldosterone and prostaglandin E1 may also play a role. If this sounds more like a boring medical lecture than an article about bodybuilding, consider the following:

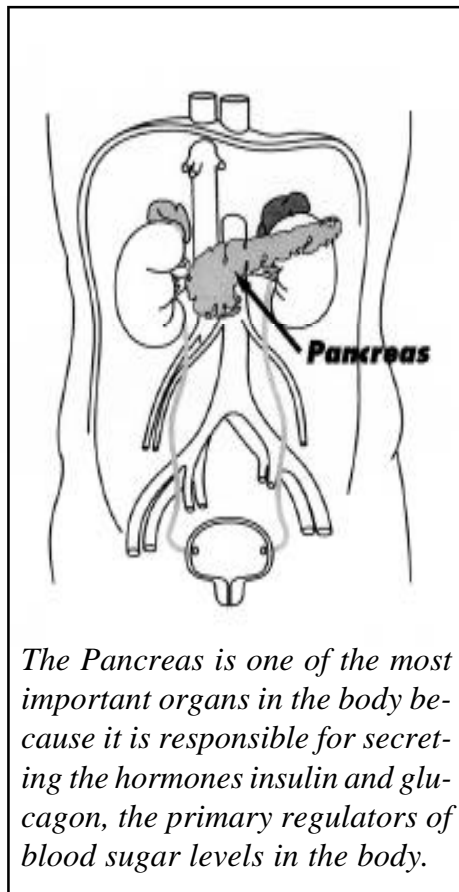
1. Muscle growth and fat loss are controlled almost entirely by these hormones. (Have I got your attention now?) You're probably asking yourself, "But I thought this was determined by diet and exercise?" Yes, diet and exercise do determine muscle growth and fat loss, but these effects are mediated by hormones. Your diet and exercise habits set up a "hormonal environment" inside your body which determines if nutrients will be stored in the lean compartment or the fat compartment. This is how nutrient partitioning works. Does this mean that if someone injects growth hormone and insulin he can get lean and muscular without having to exercise? No, it doesn't work that way. Exercise is still required, for reasons we'll explain in Part III of this series.

2. If two groups of rats are fed and exercised the same, they weigh the same, just as you would expect. If one group is injected with insulin, however, that group becomes very fat (1,2). Furthermore, if another group is injected with glucagon, those rats lose weight [fat] (2). These hormones, insulin and glucagon, are perhaps the most important factors in determining body composition.

3. The composition of your diet (the amount of protein, carbohydrate and fat)

seems to be as important as its caloric content in determining whether or not it will make you fat (1). If your metabolic rate is around 2,000 calories a day, two thousand calories from pizza will tend to make you fat. But 2,000 calories from chicken, rice and broccoli will tend to make you lean. Why? Because different foods have different effects on your body's hormones which control energy usage and fat storage.

4. Over 90% of people who lose weight by caloric restriction return to their original weight within two years (1). This is because there is a weight regulating center in your hypothalamus which tries to maintain a constant body weight. (Remember from last month that the hypo-



The Pancreas is one of the most important organs in the body because it is responsible for secreting the hormones insulin and glucagon, the primary regulators of blood sugar levels in the body.

thalamus and pituitary gland together represent the master endocrine gland of the body, controlling all of your hormonal responses.) It works like a "fat thermostat" by controlling your hunger level and your body's metabolic rate (its rate of energy expenditure). These effects are mediated by the nervous system and by hormones and enzymes involved in fat metabolism. If you want to change your body weight, or your body composition, you have to change the set point. The ratio of insulin to glucagon is perhaps the most important determinant of the set point (2) and we'll teach you how to control it in this article.

5. We all know examples of overweight people who starve themselves on 1,000 calorie a day, only to remain fat. We also know that some bodybuilders eat 6,000 to 8,000 calories a day and are extremely lean and muscular. How can this be? Obese people are very rarely overweight because they overeat, but rather because the way they eat and their lack of exercise raise the set point and act to channel calories to fat stores (1). The bodybuilders have learned how to channel their calories to the lean compartment and to minimize fat stores.

This is what nutrient partitioning is all about. At Parrillo Performance we've been teaching people how to do it for years. (We were doing it before it was in, as they say.) We've had great success helping amateur and professional bodybuilders climb the ranks, and non-bodybuilders all over the country have used the same approach to lose weight permanently.

So how do you get control of your hormones and use this information to be a better bodybuilder? By careful control of your diet and exercise habits. The most important hormones involved in muscle growth are growth hormone (whose effect is largely mediated by the paracrine

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hormone IGF1), insulin and testosterone (3). The most important hormones in fat loss are insulin (lack of insulin, that is), epinephrine, growth hormone, glucagon, thyroid hormone and cortisol (3). Most of these can be controlled by diet and exercise and will fall within optimal levels if you follow our nutrition and training guidelines.

The best place to start in explaining these hormones is with insulin and glucagon. As mentioned earlier, these hormones are among the most potent determiners of fat storage and fat loss. Luckily for us, the levels of these hormones are entirely determined by diet, so we can control over them by carefully regulating what we eat. Insulin and glucagon are both produced by the pancreas, but have exactly opposite effects. Their chief concern is the regulation of blood sugar (glucose) levels. Your brain requires a constant supply of glucose for fuel, so the blood glucose level is tightly regulated to make sure the brain never runs out of gas.

When you eat carbohydrates they are digested and absorbed by the small intestine and transported directly to the liver via the portal vein. Essentially, all of the carbohydrate you eat is converted to glucose by the liver before being released into the bloodstream. After a meal your blood glucose level rises as carbohydrates are released. This rise in blood sugar triggers a release of insulin from the pancreas. Insulin is required to help move glucose into cells by a process called "facilitate diffusion." Once inside cells, the glucose is burned for energy or stored as glycogen. Everything is fine so far. The problem arises when carbohydrates are released into the bloodstream too fast. This causes too much insulin to be released. When insulin levels get too high, some of the carbohydrate is converted to fat instead of being stored as glycogen. Also, if insulin levels get too high this actually causes too much sugar to be moved into cells. This results in "hypoglycemia," which means low blood sugar. If your blood sugar is too low you feel very tired. Simple sugars cause your blood sugar level to spike, then paradoxically to decrease

to a lower level than before (because of insulin over-release).

This is why the rate of digestion of your meals is important. On the Parrillo diet you stay away from foods containing simple sugars (sweets, fruit, dairy products) and refined carbohydrates (bread and pasta) because these are released into the bloodstream too fast, causing too much insulin to be released. This channels calories to fat stores—the opposite nutrient partitioning we want. These foods also have the effect of raising the set point—the amount of fat your hypothalamus programs your body to store (1).

Combining protein and fibrous carbs with your starches, and avoiding simple and refined carbohydrates, slows the release of glucose into the bloodstream resulting in a lower, but longer, insulin release. This gives you a uniform energy level and channels calories toward muscle and away from fat.

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In summary, the most important role of insulin is to regulate blood glucose levels. It does this by moving glucose into cells after a meal. It also increases the use of glucose for energy and increases glycogen stores. Too much insulin has the effect of promoting fat storage.

Glucagon is another hormone secreted by the pancreas, but it has the opposite effect of insulin. An increase in

blood sugar triggers a release of insulin but inhibits glucagon release. Glucagon is released several hours after a meal when blood sugar levels drop. Glucagon has the effect of reducing glucose for energy and stimulating breakdown of body fat and the use of fat for energy. Glucagon also stimulates the glycogen breakdown. The net result of glucagon is to raise the glucose levels back to normal and to signal the body to begin using fat for energy since it's running low on carbs. This is how the insulin-glucagon axis acts to regulate blood sugar levels. Insulin decreases blood sugar by moving glucose into the cells, stimulating glucose burning for energy and increasing glycogen storage. Glucagon acts to increase blood glucose levels by stimulating glycogen breakdown, stimulating glucose synthesis (by a process known as gluconeogenesis) and by shifting the metabolism from carb-burning to fat-burning.

This is why you have to eat relatively more carbohydrates during the growth season and reduce carbs during the pre-contest diet. Insulin is an anabolic hormone, acting to stimulate growth. Glucagon acts to stimulate fat loss. The insulin to glucagon ratio is determined entirely by the ratio of carbohydrate to protein in your diet (3,4), so you can control it exactly. The insulin:glucagon ratio is believed to be one of the most important factors (if not the most important factor) in determining your set point (2). The precise levels of protein and carbohydrate to eat in order

to optimize these hormones to maximize muscle growth or fat loss are described in detail in the Parrillo Performance Nutrition Manual. First, you want to meet your protein requirement by eating 1.0 to 1.5 grams of protein per body of body weight per day. Next, limit fat calories to 5% of your total daily caloric intake. Last, make up the remainder of your calories with a combination of carbs

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and CapTri. For weight loss, you generally want to limit carb:protein ratio to 1.0:1.5 and use more CapTri. For muscle gain you will want to increase the carb:protein ratio as well as increasing total calories.

Of course, there is considerable biochemical variation among individuals. Hi-Protein Powder™ and Pro-Carb Powder™ are very useful tools for dialing in your own body's optimal insulin:glucagon ratio. To gain lean body mass, meet your body's protein requirement then slowly add in more Pro-Carb™ until you find the optimal caloric level and insulin level for your body to gain lean mass. To lose fat you want to decrease carbs while increasing protein and CapTri®. Hi-Protein™ and Pro-Carb™ are a convenient way for you to experiment and find how to optimize your body's hormonal responses. We've all had the experience of going to the trouble of weighing our food and filling out our Diet Trac Sheets only to find out the numbers don't work out right and we have to do it all over again. Hi-Protein™ and Pro-Carb™ are perfect for adjusting your dietary intake from food to make your numbers work out right on your Diet Trac Sheets.

One last thing about insulin. In addition to enhancing transport of glucose inside cells, it is also required for transport of certain amino acids into cells. These include the branched chain amino acids (3), and this is why it is important to take your Muscle-Amino Formula™ with meals and not on an empty stomach. It has been found that neither insulin nor growth hormone alone is sufficient to stimulate growth—you have to have both of them together at the same time (3). This at least partly due to the fact that these two hormones act to transport different sets of amino acids inside cells, and you need all of the amino acids present at the same time in order for growth to occur (3).

How do insulin and glucagon exert their effects over carbohydrate and fat metabolism? By activating or inhibiting the key regulatory enzymes which carry out these processes (5). Insulin acts to in-

crease enzymes involved in the conversion of glucose to energy and enzymes carrying out glycogen synthesis, and to inhibit the enzymes of glucose synthesis and glycogen breakdown.

[For those of you technically inclined, this means that insulin increases the activity of glucokinase and phosphofructokinase, which increases glycolysis (the first stage in the conversion of glucose to energy). Insulin also decreases gluconeogenesis—the synthesis of glucose from amino acids. Insulin increases the activity of glycogen synthase, the key enzyme

These two hormones act to stabilize blood sugar levels—insulin by decreasing blood sugar and glucagon by increasing blood sugar. These effects are brought about by exerting control over the enzymes regulating carbohydrate metabolism.

regulating glycogen synthesis, and inhibits phosphorylase A, the enzyme responsible for glycogen breakdown.]

Glucagon has the opposite effects. These two hormones act to stabilize blood sugar levels—insulin by decreasing blood sugar and glucagon by increasing blood sugar. These effects are brought about by exerting control over the enzymes regulating carbohydrate metabolism. Regarding fat metabolism, insulin acts to activate the two most important enzymes regulating fat synthesis and storage. Glucagon inhibits these same two enzymes. In addition, glucagon initiates a cascade of events resulting in mobilization of fatty acids from fat stores. The fats are then transported to the muscles and used for energy. This is why this information is important for bodybuilders.

[Again, for those of you attuned to strict biological terminology, glucagon decreases phosphofructokinase and gly-

cogen synthase, which decrease glycolysis and glycogen synthesis, respectively. Glucagon also increases the activities of fructose-1,6-biphosphatase and phosphorylase, which increases gluconeogenesis and glycogenolysis, respectively.]

[Regarding fat metabolism, insulin acts to stimulate acetyl-CoA carboxylase and lipoprotein lipase, the most important enzymes regulating fat synthesis and storage, respectively. Glucagon inhibits these same two enzymes. In addition, glucagon activates adenylate cyclase which initiates a cascade of events resulting in mobilization of fatty acids from fat stores. The fats are then transported to the muscles and used for energy.]

In summary, insulin acts to increase enzymes involved in the conversion of glucose synthesis, and to inhibit the enzymes glucose and glycogen breakdown. Glucagon has the opposite effects. These two hormones act to stabilize blood sugar levels—insulin by decreasing blood sugar and glucagon by increasing blood sugar. These effects are brought about by exerting control over the enzymes regulating carbohydrate metabolism.

By now you know that insulin is a powerful growth-promoting hormone — some people consider it the most powerful anabolic hormone. Does this mean we want to overeat carbohydrates or eat simple sugars to get our insulin levels really high? No, obviously not. Although insulin is absolutely required for muscular growth since it transports certain amino acids inside cells, it is not very selective in its actions. It promotes growth of fat cells as well as muscle cells (3,5). When insulin levels get too high some of the carbs “spill over” into fat stores.

When dieting, do we want to go on a zero-carb diet to minimize insulin and maximize glucagon? No way. Under these conditions muscle growth is impossible because some of the amino acids cannot get inside cells (3). However, your body continues to undergo a process called “obligatory protein loss,” which is the process of disposing of worn out proteins.

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(Proteins are the machinery of the cell, and they get worn out like any other machine.) This amounts to the obligatory loss of proteins from the body at about the rate of 30 grams per day, during starvation (3). When consuming a normal diet, these worn out proteins are simply replaced, but this can't happen if the amino acids can't get inside cells. So if you want a sure way to lose lean mass, go on a zero-carb diet. During a zero-carb diet the body is in a very catabolic state, and breaks down proteins to supply amino acids which are converted to glucose, which the brain requires for fuel. This makes the problem even worse.

Of course you want to adjust your carb:protein ratio, but moderation is the key. Going to extremes is asking for disaster. People have actually died from zero-carb diets even while getting plenty of protein, because they lost so much protein from their heart muscle. In general, stick to the formula in the Nutrition Manual, as outlined above. That will put you real close to optimal. Experiment with Hi-Protein™ and Pro-Carb™ to find the perfect ratio for you. Learning to control the insulin-glucagon axis is one of the most important aspects of nutrient partitioning, and it will take you a long way toward a top physique.

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Maximizing Anabolic Drive

by John Parrillo

In the previous bulletins we've been discussing nutrient partitioning and dietary strategies to channel nutrients to the lean compartment and not to fat stores. We saw that muscle gain and fat loss are controlled largely by hormones — chemical signals sent out by the endocrine glands which direct the body's metabolism. We discussed the insulin-glucagon axis in detail and saw that it has a major influence in determining the set point in the hypothalamus — the weight regulating center of the body that decides how much fat we will carry (1,2). Insulin is the body's most powerful anabolic hormone, acting to transport glucose and amino acids into cells. This supplies energy and the building blocks for growth. Insulin is required for muscular growth, and indeed for life. Glucagon has the opposite actions of insulin. It moves glucose and amino acids out of cells and into the bloodstream when blood sugar gets too low. These two pancreatic hormones work in balance to provide a relatively uniform blood glucose level, to ensure that the brain doesn't run out of fuel.

The good news is that insulin and glucagon levels are determined solely by diet, so we can exert great control over these hormones by our eating habits. The Parrillo Performance Nutrition Program was designed to take advantage of this fact to keep insulin and glucagon at just the right levels to build muscle and burn fat. Last month we talked about how to use Pro-Carb Formula™ and Hi-Protein Powder™ to fine-tune these hormone levels to optimize your body's metabolism.

The bad news, however, is that insulin is a powerful stimulus for fat growth as well as muscle growth (3,4). It stores fat inside fat cells as well as it stores protein inside muscle cells. This is why on the Parrillo Program meals are structured so as to release carbs into the bloodstream slowly. This results in a lower and more uniform insulin level, which helps minimize any fat storage. This is also why you should stay away from any products high in simple carbohydrates. These products elicit a rapid, large insulin

release. Any time you empty a lot of carbohydrate calories into your bloodstream very rapidly and have a high insulin level you will store those calories as fat. High sugar products would be better called "fat optimizers." The body can only build muscle so fast, but it has an unlimited ability to store fat. Muscle building is a slow and difficult process, and it works better when you supply your body with slow and steady supply of energy and nutrients. This also provides a more uniform energy level, instead of the periods hypoglycemia you experience after eating simple sugars.

The bad news about glucagon is that, although it stimulates fat breakdown (lipolysis), its actions are mostly limited to the liver (3,4). Like insulin, glucagon is released from the pancreas and transported directly to the liver by the portal vein. While enough insulin is released to effect the whole body, glu-

Epinephrine, is the body's most powerful stimulus for fat breakdown. It is produced by the adrenal glands, two small glands located one just above each kidney.

cagon is released in smaller amounts and most of it stays in the liver. Therefore, glucagon is not a very potent stimulator of lipolysis in peripheral tissues, such as body fat stores.

But don't get discouraged, the insulin-glucagon axis is still one of the most important controllers of nutrient partitioning — it's just not the whole story. This month we'll begin our discussion of three other hormones that complete the puzzle: growth hormone, testosterone and epinephrine. Once you learn how to control these hormones and add them to your arsenal you're likely

to see the best gains in your life, and get more ripped than you though possible. Now we're pulling out the big guns!

Epinephrine, more commonly known to the layman as adrenaline, is the body's most powerful stimulus for fat breakdown (3,4). It is produced by the adrenal glands, two small glands located one just above each kidney. Actually, epinephrine serves not only as a hormone by also acts as a neurotransmitter in the nervous system. This underscores the relationship of the nervous system and the endocrine system working together as a control and communication network to provide instructions to the body. Nerve impulses are conducted to the center of the adrenal gland, the adrenal medulla, by the sympathetic division of the nervous system. This triggers epinephrine to be released into the bloodstream.

Epinephrine has many effects. One you've probably noticed is the "fight or flight" response that occurs when you're really scared or suddenly startled. When your skin and lips turn pale, you feel cold and clammy, you start sweating and your heart pumps really hard and fast — that's epinephrine. It's a reaction animals have when they're confronted by an enemy and have to either fight or run away. It's the feeling of being "scared to death" that most of us have experienced at one time or another. It's the "adrenaline rush" you get from bungee jumping. This surge of epinephrine is mediated by a large sympathetic discharge in the adrenal medulla. This gland has a large blood supply for its size and the epinephrine is rapidly carried throughout the body. It primes your muscles for action and mobilizes fat from adipose stores to provide energy. It increases your heart rate, blood pressure and the force of your heart's contractions.

Under normal conditions, epinephrine is delivered to fat cells mostly by direct innervation of the fat cells by the sympathetic nervous system, rather than systematic release to the whole body from the adrenal medulla. Its release is increased during exer-

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cise, and this is the primary mechanism whereby exercise serves as a stimulus for fat loss. Epinephrine binds to receptors on fat cells and generates a metabolite called cyclic AMP, or cAMP. cAMP activates an enzyme called protein kinase, which in turn activates another enzyme called hormone sensitive lipase. Hormone sensitive lipase breaks down triglycerides (the molecular form in which body fat is stored) into free fatty acids (FFAs) and glycerol. The FFAs then leave the fat cell and are carried by the blood to the muscles, where they are burned for energy (3,4). This is how exercise works to help you lose fat.

While insulin and glucagon are controlled entirely by diet, the most effective way to control growth hormone, testosterone and epinephrine is by exercise (5,6). This is why exercise is required to gain muscle and lose fat. If you try to lose weight by cutting calories, about half of the weight you will lose will be muscle. Conversely, if you gain weight simply by increasing calories (without exercising) you'll just get fat. Exercise is required to set up the proper hormonal milieu allowing selective fat loss and muscle gain. The favorable effects of exercise in increasing muscle mass while decreasing fat stores are mediated largely through growth hormone, testosterone and epinephrine. Therefore, to really fine tune nutrient partitioning to sculpt the ultimate physique, we have to talk about effective training strategies to optimize these hormones.

Growth hormone (GH) is the most important hormone responsible for normal growth during childhood. Without growth hormone, a person will never attain adult stature. Growth hormone has profound effects on the growth of the skeleton as well as the muscles. Testosterone and estrogen produced during puberty cause the skeleton to

mature and stop growing, but growth hormone still promotes muscle growth and fat loss in adults. Growth hormone is released from the pituitary gland when it receives the appropriate signals. One of these signals is "growth hormone releasing hormone" (GHRH) which comes from the hypothalamus.

There are several things you can do to naturally increase your GH levels. One is to get a good night's sleep. Growth hormone is released maximally during sleep, normally about three hours after you fall asleep. Trying to build muscle without getting enough rest is nearly impossible. Second, GH release is increased during and just after intense exercise (5,6). The most effective training style for increasing GH release is high volume training (5,6,7). We recommend a mixture of low rep, medium rep and high rep work to maximally stimulate all the muscle fibers as well as train the nervous system. This results in optimal increases in size and strength. The ultimate training program for bodybuilders is described in the Parrillo Performance Training Manual and High Performance Bodybuilding book. Third, eat a high protein diet. This not only stimulates GH release, but also provides the building blocks you need to build new muscle tissue. Fourth, certain combinations of amino acids have been shown to increase GH release and result in increased lean body mass (7). Enhanced GH Formula™ contains the most effective combination ever developed. Take it on an empty stomach (this is important) just before training and before bed.

In the following bulletins we'll continue our discussion of muscle-building and fat-burning hormones and talk more about growth hormone and testosterone. The most exciting part of the story is yet to come! Of course, merely having a detailed intellectual

understanding of how nutrition and exercise come together in your body to build muscle and burn fat does nothing to achieve those results. It's up to you to put this information to use in the gym and at the dinner table. Don't forget the basics of the Parrillo Philosophy: dedication, consistency and hard work. So train hard, eat right and do your aerobics. And have a great summer!

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Growth Hormone: The Ultimate Weapon

by John Parrillo



In this bulletin we're pulling out the ultimate weapon — growth hormone. This is the most important hormone for bodybuilders, acting as a powerful stimulus for muscle growth and fat loss. Many of the effects of exercise in increasing muscle mass and decreasing body fat are mediated by growth hormone. The most effective training strategies are those which maximize growth hormone release. Parrillo Performance knows exactly how to eat and how to train to maximize this most important controller of nutrient partitioning. And like always, we're here to show you how. If you're willing to train hard enough, we'll help you reach the stars.

Every athlete who has struggled to build muscle is painfully aware of the fact that you have to lift weights to do it. In fact, you have to lift weights very intensely and consistently over a period of some time (months to years) to accumulate significant increases in muscle mass. Since muscles are made from nutrients in the food we eat, you may logically ask why can't we build muscle just by eating the right foods? The answer to this ques-

tion takes us back to the theme of this series: hormones.

Hormones are ultimately responsible for the process of tissue remodeling — that is, the process of laying down new muscle tissue. Although you can exert great control over some hormones by diet alone (refer back to the previous bulletins in this series), exercise is required to generate the complete hormonal spectrum which will result in muscle gain and fat loss (1,2). Furthermore, the damage to muscle tissue which results from exercise training (especially the eccentric, or lowering phase of muscle contraction) serves as a stimulus to the muscles more responsive to the growth-promoting effects of anabolic hormones (1).

Growth hormone (GH) is the most anabolic substance in the human body (3,4). In a study of old men (whose growth hormone levels are diminished), it was found that GH administration promoted an increase in muscle mass and a decrease in body fat even in the absence of exercise training (3,4). Growth hormone is anabolic, meaning that it acts to promote incorporation of nutrients into new body tissues. This includes increasing protein synthesis in the muscle tissue (5,6). Part of this effect is believed to be due to GH promoting transport of certain amino acids inside muscle cells (5). Notably, insulin also acts to transport a different set of essential amino acids, so you need adequate amounts of GH and insulin present at the same time to stimulate muscle growth (5). GH also has a lipolytic effect, which means it mobilizes body fat from adipose depots and increases the use of fat for energy (5,6). This in turn spares carbohydrates so glycogen stores are preserved (5,6). GH is probably the most important hormone for bodybuilding since it has powerful actions in building muscle and burning fat.

The most important role of growth

hormone is in promoting growth during childhood. Without GH, normal adult stature will not be achieved (5,6). Growth hormone acts to promote growth of all tissues of the body except the nervous system. GH levels reach maximal levels in the late teens and gradually decline with age. The high levels of GH and testosterone in young adult males explain why most bodybuilders make their best gains during their late teens and twenties. This again underscores the central role of hormones in bodybuilding.

Although I've discussed this before, it is so important as to bare repeating: the central reason behind all of your bodybuilding activity, including both diet and training, is to manipulate your hormone levels so as to promote muscle gain and fat loss. Your body's level of muscle mass and body fat are determined by hormones and by the set point of your hypothalamus. By following the guidelines in this series and in the Parrillo Nutrition and Training Manuals you will adopt a lifestyle which optimizes anabolic drive and sets up the proper hormonal environment for achieving a top physique.

During the next couple of bulletins I will explain in detail the physiology of growth hormone, including its mechanisms of release, its actions and what you can do to control your GH levels for maximum results. As you know by now, hormones do not work alone in the body. It is the combined interaction of all the hormones which generates the physiological adaptations to exercise. Therefore, I will discuss growth hormone in the context of the other hormones with which it synergizes to produce its effects. I have decided to organize this discussion around some of the most basic and important questions about growth hormone. If the discussion sounds a little medical in places, bear with me. You will come away with a thorough understanding of growth

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hormone and how to control it. Get ready to annihilate the competition.

1. Exactly what is growth, and what is the difference between linear growth, mass increase and obesity?

The common feature of growth is an increase in mass (body weight). The common definition of growth refers to the organized addition of new tissue that occurs normally in development from infancy to adulthood (6). Bodybuilders are a bit unusual in that they continue to grow after reaching adulthood. This is largely due to the effects of intense exercise in increasing growth hormone. Normal growth involves both linear growth (increase in body length or height) and mass increase (increase in body weight). Obesity specifically refers to growth of fat stores out of proportion to the rest of the body. Quantitatively, anything above 30% body fat is commonly considered obese. Growth is normal and healthy; obesity is not. Abnormal growth can be caused by an excess or deficiency in growth hormone. GH causes partitioning of nutrients to the lean compartment and away from fat stores. Administration of GH will increase muscle mass and decrease body fat, and a deficiency of GH will result in excess fat accumulation.

2. What are the main stages of normal growth and the hormones that stimulate growth in each?

Prenatal: Hormonal control during prenatal development is largely unknown, but insulin is believed to be important (6). Human placental lactogen, hPL, is probably also involved.

Infantile (0-1 years): Insulin is required and possibly other unknown hormones as well (6). Interestingly, GH and T3 (thyroid hormone) are not required during prenatal and infantile growth (6).

Juvenile (1-12 years): GH is the most important, but there is also a strict requirement for T3 and insulin (5,6). Vitamin D

is also required.

Adolescent (age 10-14 for females, 12-16 for males): The sex steroids are responsible for the adolescent growth spurt, closure of the epiphyseal plate (see below) and attainment of final adult height. GH, T3, vitamin D and insulin are still required for normal growth during this time. Glucocorticoids are also required in normal levels for normal growth but its action is mainly permissive (6). Permissive actions of hormones describe effects of hormones on enzyme systems so as to allow other hormones to exert their regulatory effects. The permissive hormones do not stimulate growth directly, but rather allow other growth-promoting hormones to be active.

3. What is the difference between growth-regulating hormones and local growth factors?

Hormones are released into the bloodstream to exert their effects on target tis-

As you know by now, hormones do not work alone in the body. It is the combined interaction of all the hormones which generates the physiological adaptations to exercise.

issues throughout the body, while growth factors act mainly locally (as autocrines or paracrines) to stimulate growth. The most important growth-regulating hormones are GH, T3, insulin and the sex steroids. Most growth factors act as regulators of local processes such as wound healing, tissue repair, regeneration or ordinary replacement of aged cells, but some are found in the circulation and may function as true hormones. IGF1 (somatomedin C) is especially important in this regard in mediating many of the actions of GH. See the below for more information on IGF1.

4. What are the other requirements for normal growth in addition

to hormones and growth factors?

Proper nutrition (including energy, amino acids, vitamins, minerals and essential fatty acids) rest, and a good psychosocial environment are all requirements for growth (6). Mental state (emotional state) can directly influence normal growth in humans. No doubt this effect is mediated by the hypothalamus, since it connects the endocrine system to the mind. If you're eating and training right, but are totally stressed out about work or some personal problem, you're probably not going to make very good gains. The mind is very important to bodybuilding. You must maintain a positive and aggressive attitude and not be distracted by outside stresses.

5. What are catch-up growth and compensatory growth?

Catch-up growth is a period of growth at greater than the normal rate to recover from a time when growth was retarded, as during illness. Notably, increased levels of hormones (including GH) are NOT required during catch-up growth. Compensatory growth is growth of an organ to compensate for damage to that organ or its pair. For example, if one kidney is removed, the remaining kidney will grow larger. Increased hormone levels are probably not needed for compensation by the liver and kidney, although IGF1 may be increased. Compensatory growth of the adrenal gland is accompanied by increased levels of ACTH (6). Many athletes who are over-trained or under-nourished experience a growth spurt when they correct the problem. In the case of over-training, the problem is likely due to elevated cortisol levels, which are catabolic.

6. What are the roles of insulin, glucocorticoids, sex steroids and thyroid hormone in normal growth? How do these relate to growth hormone?

Insulin: Optimal concentrations of insulin are required for normal growth during postnatal life. Insulin stimulates protein synthesis and inhibits protein breakdown. Without insulin, normal responses to GH are not seen and protein

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breakdown is severe. Insulin promotes growth primarily by shuttling nutrients (glucose and some amino acids) inside cells, providing energy and the building blocks for protein synthesis. Note that insulin and GH must both be present at the same time for normal growth to occur. Guyton (5) suggests that this is because insulin and GH each shuttle a DIFFERENT compliment of essential amino acids inside cells, and of course all of the essential amino acids must be present at the same time for protein synthesis (and thus growth) to occur. Neither insulin nor GH alone is sufficient to support normal growth — it takes optimal levels of all the body's hormones to produce optimal health and optimal gains. As noted in a previous bulletin, excess insulin cannot create muscle mass, but it will promote fat storage. It's not the calories in sugar that make you fat — it's the insulin response (7,8).

Glucocorticoids: Glucocorticoids (primarily cortisol) promote optimal function of a wide variety of organ systems, but do not have direct growth promoting actions. Excess GC's inhibit growth by the catabolic effects of cortisol (increased protein breakdown). Normal levels of GC's seem to be needed to permit optimal function of the other hormones. The concept here is that glucocorticoids act to stimulate (or maintain) optimal levels (amounts) of metabolic enzymes, whose activities in turn are regulated by the other hormones. GC's sort of set the stage and make sure all of the machinery is in place. Cortisol functions to make sure the key regulatory enzymes are present in sufficient amounts to allow allosteric regulation (enzyme regulation via small effector molecules such as metabolic intermediates) and enzyme regulation by other hormones. Also, cortisol is important in maintenance of glucose levels and resistance to stress, which intuitively would seem important for normal growth.

Sex Steroids:

Androgens: Androgens (such as testosterone) are potent stimulators of linear growth in children whose epiphyses (the growing ends of bones) have not yet closed. Androgens can promote some growth in the absence of GH, but combined treatment with androgens and GH together promote more rapid growth than the sum of the two hormones alone. This is an example of the synergistic action of certain hormones. Much of the growth-promoting action of androgen appears to be mediated by increased GH secretion

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(6). Androgens increase the frequency and amplitude of GH secretory pulses (6). In addition to promoting linear growth, androgens also stimulate growth of muscle, and this can occur in the absence of GH or T3. Androgens bind to nuclear receptors and the hormone-receptor complex in turn binds to chromosomes and activates transcription of specific genes.

Estrogens: In normal girls, the adolescent growth spurt usually occurs before estrogen secretion is sufficient to initiate breast development and is probably attributable to very low concentrations of estrogens (6). Paradoxically, concentrations of estrogen sufficient to promote breast development actually inhibit growth (6). Stranger still is the fact the concentrations of estrogens which inhibit growth increase GH secretion. What is the basis

for the complex interaction between estrogen and GH? High concentrations estrogens appear to inhibit growth by interfering with the actions of GH (6). Estrogens also antagonize the effects of GH on nitrogen retention. Of course, estrogen is also responsible for the characteristic female fat distribution. The differential effects of estrogen and testosterone, as well as their different interactions with GH, explain why males on average contain 50% more muscle mass than females and why females have a higher body fat percentage.

At the same time that gonadal steroids stimulate linear growth, they also accelerate closure of the epiphyses (the sites at the ends of the bones where bone elongation occurs) and therefore limit the final height that can be attained. This is why linear growth stops a few years after puberty. GH and the sex steroids are still present and active, but the ends of bones are permanently sealed and cannot grow anymore. Flat bones, such as the bone in your forehead, can still increase in thickness, however. People who abuse growth hormone experience this condition, known as acromegaly.

Thyroid Hormone: Thyroid hormone is present in two forms, known as T3 and T4. Most of the circulating hormone is in the form of T4 which is converted to the more active T3 form inside target cells.

Thyroidectomy (removal of the thyroid gland) has nearly as devastating an effect on growth as does hypophysectomy (removal of the pituitary gland — the body's source of GH). Restoration of T3 and T4 promptly reinitiates growth. T3 and T4 have little if any growth promoting effect in the absence of GH however. T3 acts to promote the actions of GH at three levels: GH synthesis, GH secretion and GH action. Plasma concentrations of GH are very low in the absence of T3 or T4. This

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action is independent of GHRH (growth hormone releasing hormone) and appears to be exerted directly at the level of gene transcription. In addition to its permissive effects on GH synthesis, T3 maintains normal responsiveness of somatotropes (the cells that make GH) to GHRH. Failure of growth in thyroid deficient individuals is largely due to GH deficiency. However, even large amounts of GH cannot sustain normal growth in thyroidectomized animals unless thyroid hormone is also given. Thyroxin decreases the amount of GH needed to stimulate growth (increases sensitivity) and exaggerates the magnitude of the response (increases efficacy). T3 and T4 seem to potentiate the effects of GH on long bones and to increase its effects on protein synthesis in muscle and liver.

In summary, GH interacts with insulin, the sex steroids and thyroid hormones directly to stimulate growth. These actions are not only crucial to growth during childhood but are also at the very core of the adaptations which occur in response to exercise. Thyroid hormone is required for optimal GH release and function. Glucocorticoids (cortisol) are also required in normal levels to play a supporting role. Cortisol ensures that the metabolic enzymes are present in sufficient amounts so that GH, insulin and testosterone can exert their effects. If cortisol is too low, optimal growth cannot occur because enzyme levels are too low, and if cortisol is too high you will actually lose mass because high cortisol levels are catabolic and promote protein breakdown. Epinephrine is released during exercise and is the most potent stimulus for fat breakdown. It is the interplay of these hormones in the proper balance that makes a great bodybuilder. These hormones control muscle and fat metabolism, and the strategy behind a bodybuilding diet and training is to control them to produce a lean, muscular body.

7. What exactly is the molecular structure of human growth hormone?

GH is a protein. Ninety percent of GH produced by somatotropes (cells of the

pituitary gland where growth hormone is made) is comprised of 191 amino acids and has a molecular weight (MW) of about 22,000 daltons (6). The other 10% has a MW of 20,000 and lacks 15 amino acids corresponding to residues 32 to 46 of the 22,000 MW form. Both forms are products of the same gene and arise from differential RNA splicing. Both forms are secreted and have similar growth-promoting activity, although the metabolic effects of the 20K form are reduced. GH is stored in the anterior pituitary and is the most abundant of the anterior pituitary hormones. As much as half of the GH in plasma protein and a substantial fraction is in the form of dimers or oligomers which are inactive. hGH used for therapy today is produced in bacteria from the cloned gene.

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8. Describe the major effects of GH on growth (linear and mass) and metabolism of carbohydrate, protein and fat.

Linear growth: Linear growth is a consequence of elongation of the skeleton, especially the spine and leg bones. Proliferation of chondrocytes (cartilage cells) at the epiphyseal border of the growth plate is balanced by cellular degeneration at the diaphyseal end, so in the normally growing individual the thickness of the growth plate remains constant as the as the epiphyses are pushed farther apart by the elongating shaft of the bone (6). In the absence of GH there is severe atrophy of the epiphyseal plates, which be-

come narrower as proliferation of cartilage progenitor cells slows markedly. Conversely, after GH is given to a hypopituitary subject, resumption of cellular proliferation causes columns of chondrocytes to elongate and the epiphyseal plates to widen. Bone growth is also accompanied by an increase in diameter, which involves bone remodeling. Treatment with GH often induces a transient increase in urine calcium and phosphorus excretion, reflecting stimulation bone remodeling.

Mass: GH increases lean body mass by stimulating protein synthesis and increasing nitrogen retention. GH-deficient individuals have a relatively high proportion of body fat. Treatment with GH causes a decrease in body fat accompanied by an increase in body protein, mostly muscle.

Carbohydrate Metabolism:

Sometimes, particularly after a period of glucose deprivation, GH has an insulin-like effect in increasing glucose uptake and utilization. This anomalous effect disappears quickly and its physiological significance is a mystery. After about two hours, glucose metabolism is inhibited in muscle and adipose tissue. There is a decrease in glucose uptake and muscle glycogen stores are preserved.

Fat Metabolism: In adipose tissue GH promotes breakdown of stored triglyceride (body fat) which increases plasma free fatty acids (FFA). Since glucose uptake is suppressed by GH, fat synthesis is also suppressed. These effects, combined result is a net loss of body fat.

Protein Metabolism: As already discussed, GH promotes nitrogen retention and increases protein synthesis, mainly as muscle. Part of this effect may be due to GH's role in transport of certain amino acids inside cells (5). Immediately after GH injection, plasma amino acid concentrations decrease as a result of rapid uptake and conversion of protein.

The thing to remember is GH decreases glucose uptake and utilization and spares glycogen, it increases use of fat for energy by mobilizing fat stores and it

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increases protein synthesis. The net effect is to make the body leaner and more muscular. Many of the effects of exercise in making the body leaner and more muscular are mediated by an exercise-induced increase in growth hormone (1,2).

9. How do bones grow and how does GH affect this process?

Growth of long bones occurs by a process called endochondrial ossification, in which proliferating cartilage is replaced by bone. Proliferation of chondrocytes (cartilage cells) occurs at the epiphyseal plate — the ends of the bones where growth occurs. Frequent division of small cells in the germinal zone at the distal end of the growth plate provides for continual elongation of the columns of chondrocytes. GH stimulates proliferation of chondrocytes, and thus bone elongation. GH also stimulates osteoblastic progenitor cells to proliferate causing bone remodeling and an increase in bone diameter. Lack of GH greatly retards bone growth, and without GH normal height cannot be achieved.

10. How are the effects of GH mediated at the cellular level? What is the “somatomedin hypothesis” and the “dual effector hypothesis?”

The SOMATOMEDIN HYPOTHESIS explains the observation that GH alone is not sufficient to stimulate proliferation of cartilage progenitor cells, or protein synthesis by cartilage cells, *in vitro*. To study the cellular effects of GH, cartilage cells are isolated and grown in culture dishes. When normal blood plasma was added to the mixture, or plasma from a hypophysectomized rat which had been treated with GH, there was a sharp increase in protein synthesis, DNA synthesis and bone matrix formation. These effects could not be stimulated by adding plasma from a hypophysectomized rat which was not treated with GH. These experiments demonstrate that GH requires a factor from plasma to be active, and this factor itself is induced by GH. Thus, GH may not directly promote growth itself, but rather stimulates the liver to produce and intermediate blood-borne substance that stimulates chondrogenesis

and perhaps other processes as well. This substance was originally called somatomedin C (somatotropin mediator C). Its insulin-like effects on glucose and its molecular resemblance to proinsulin gave rise to the name insulin-like growth factor (IGF). Now, two IGFs are known: IGF-I (somatomedin C) and IGF-II. IGF-I is a small peptide (MW 7500) produced primarily by the liver. It is tightly bound to specific carrier proteins in the plasma. IGF-I can cause hypophysectomized rats to grow in the absence of GH, indicating many of the actions of GH are mediated by IGF-I.

The DUAL EFFECTOR HYPOTH-



ESIS explains the observation that injection of GH into epiphyseal cartilage of one leg of a hypophysectomized rat produces growth in only that leg. This means that things are a little more complicated than explained by the original somatomedin hypothesis. Studies with cultured fibroblasts which can differentiate into adipocytes in a manner which is absolutely dependent on GH may act directly on precursor cells to initiate differentiation. According to the dual effector hypothesis, cartilage progenitor cells

in the epiphyseal plates differentiate in response to GH and then undergo clonal expansion (cell division) in response to IGF-I, whose production is also triggered by GH. Chondrocytes and other cells can synthesize and secrete GH when stimulated by GH. IGF-I may then act as an autocrine to stimulate cell division. Thus we have two effectors, one to stimulate differentiation (GH), and one to stimulate cell division (IGF-I). IGF-I may act locally in processes such as wound healing and compensatory growth.

Apparently eccentric (lowering) muscular contractions result in tearing of myofibrils (muscle fibers) and this in some way causes local release of IGF-I which acts as a paracrine to stimulate differentiation of satellite cells into new myocytes (muscle cells). Exercise is required to induce a GH response (which in turn induces hepatic IGF-I production) and to produce the micro-trauma which serves as the stimulus for tissue remodeling.

11. How is GH secretion regulated in humans?

GH secretion is stimulated by sleep, stress, low blood glucose, an increase in certain amino acids (especially arginine, leucine, valine and ornithine) and exercise. Normally GH is secreted in an episodic fashion with maximal secretion occurring during deep sleep. GH is synthesized and stored in the anterior pituitary, and its plasma level is controlled via its rate of secretion. Its rate of secretion is controlled by two hormones in the hypothalamus: GHRH (growth hormone releasing hormone) and somatostatin (which inhibits GH release). GH secretion is thus under minute-by-minute control by the nervous system. GH secretion is also controlled by negative feedback, mediated by IGF-I. IGF-I appears to increase release of somatostatin by the hypothalamus and to reduce the responsiveness of the pituitary to GHRH. In addition to direct regulation by the hypothalamus, GH release is indirectly regulated by thyroid hormone. T3 stimulates GH release by maintaining sensitivity to somatotropes to GHRH. T3 enhances GH's actions by decreasing the amount

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of GH needed to stimulate growth (increases sensitivity) and exaggerating the magnitude of the response (increases efficacy). T3 and T4 seem to potentiate the effects of GH on long bones and to increase its effects on protein synthesis in muscle and liver.

12. How does the integrated GH concentration change with age?

GH secretion is most active during the adolescent growth spurt and persists throughout life, long after the epiphyses have closed. GH secretion gradually decreases in both men and women between ages 20-40.

13. What are the effects of excess GH in humans before and after the end of adolescent growth?

Overproduction of GH in children produces gigantism — and adult height of over eight feet may be achieved. Overproduction of GH in adulthood resulting from a pituitary tumor, or abuse of GH, produces acromegaly. This condition is characterized by thickening of the cranium and mandible and enlargement of the bones of the hands and feet. There is also abnormal growth of the ribs, liver and spleen and thickening of the skin. You never have to worry about acromegaly resulting from naturally increasing your body's own production of GH. You can naturally increase GH enough to dramatically increase muscle mass and decrease body fat, but not enough to experience the side effects of acromegaly. Acromegaly only results from pituitary disease or abuse of exogenous GH.

14. What are the effects of diet and exercise on GH?

What should I do to naturally increase GH levels? There are several things you can do as a bodybuilder to naturally increase your GH levels (9). First, eat an adequate diet containing at least one gram of protein per pound of body weight. A high protein meal increases GH release. Also remember our previous bulletin about dialing in your protein to carbohydrate ratio to optimize insulin and glucagon levels. Second, supplement your diet with Max GH Formula containing the most effective combination of amino acids for GH release ever produced (10). Use Max GH

Formula before bed and before training. Always take it on an empty stomach. Glycine is also a potent GH stimulator (3) and this may explain the well-known anabolic effects of glycine. Parrillo Performance Hi-Protein Powder and Pro-Carb Formula are fortified with significant amounts of glycine. This combination of supplements, along with the right diet, has proven over the years to be incredibly anabolic. Third, make sure you get enough sleep. Maximal GH release occurs during deep sleep. Take a nap during the afternoon if possible. Fourth, train smart. Heavy, low-rep work is known to be effective in increasing strength. This is probably due to an increase in testosterone levels and a training effect on the nervous system. High-rep work with moderate weights is more effective in stimulating GH release (1,2,9). It's a huge mistake to leave out the high-rep part of your training. While low-rep work is more effective in increasing muscle strength, high-rep work is very effective in increasing muscle size. The GH release resulting from high volume training also serves as a potent stimulus for fat loss.

Of course, you need both high-rep and low-rep work to make continuing progress. Don't get the idea that you don't have to lift heavy weights anymore. If you want to get bigger muscles, you will always have to lift heavy weights — but you also have to incorporate high-rep work for maximum development. There are several strategies for doing this. You can incorporate both heavy and light work into the same training session using a pyramid technique. Start with one or two warm up sets around 15 reps. Use a light weight when warming up and do not go to failure. Then pick a weight you can handle in good form for ten reps. Continue increasing the weight and do sets of eight, six and four reps. Take all working sets to positive failure. Then decrease the weight and do a set of 20 reps to failure. This helps pump the blood into the muscle and stimulates GH release. Lower the weight slowly, emphasizing the eccentric part of the contraction. This is especially important at the end

of a set when ATP is the muscle is depleted. ATP is required for muscle relaxation as well as muscle contraction. When a muscle runs out of ATP it "locks up" in the contracted state and cannot relax properly. This state is known as "ischemic rigor." When the muscle is in rigor and you are lowering a weight from the contracted position, the fibers cannot relax and literally get torn as the muscle elongates. If this sounds painful, it is. Most people stop a set just as this starts to happen because the pain gets unbearable. The ones who fight through the pain and crank out a few more reps are the ones who get big muscles. Sorry, but that's the way it is.

Another way to incorporate high rep work is to train in the four-to-eight rep range one week and the 12-to-20 rep range the next week. Finally, some people do a "powerlifting cycle" involving heavy, low-rep work for four-to-six weeks followed by a "bodybuilding cycle" with moderate weights and higher reps for the next four-to-six weeks. Most advanced bodybuilders have experimented with all three strategies at some point. The key is to find what works best for you. If you're at a plateau, it's probably time for a change.

To break out of a plateau, increase calories and try training less frequently by with heavier weights. If you haven't been doing any high-rep work, doing some will probably stimulate a growth spurt. Of course, there are many reasons for reaching a training plateau, but they usually relate to over-training, under-training, under-nutrition or not enough rest. Constant fatigue, loss of libido and failure to recover from workouts are signs of over-training and not enough rest. If you neglect any part of the program — high-rep training, low-rep training, aerobics, stretching rest, nutrition, or supplementation — your results will definitely suffer. The Parrillo Program is a balanced approach covering every facet of bodybuilding. You supply the hard work, consistency and dedication, and we'll supply the winning strategy.

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