

Ironman Articles

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How Muscles Perform Work

The well-established “all or nothing” theory of muscular contraction is a long first step in the direction of understanding the workings of human muscles, and more recent research on the biochemical process which takes place within muscular tissue during the contractions of individual fibers has added theoretical – if not perhaps yet practical – information to the store of existing knowledge. But concerning the effect of exercise on muscular tissue – the practical consideration which concerns us here – there is nothing even approaching scientific agreement in sight at the moment.

A recent scientific publication stated (or words to this effect) “...almost nothing is known regarding the effect of exercise upon muscles; but since it has been observed that muscles will lose both size and strength if they remain inactive for prolonged periods of time, it has been suggested that perhaps the reverse is true as well.” That is to say (my words) – MAYBE exercise will cause muscles to gain in size and/or strength, but there is NO PROOF to that effect.

This same supposedly “scientific” attitude prevented any of the then leading scientists from wasting their time investigating the obviously outrageous claims of two obscure mechanics from Ohio – since “everybody knows you can’t fly.”

An isolated example? Far from it; similar, if perhaps not so important, examples can be quoted by the dozen – I am personally convinced that they exist by the hundred, perhaps by the thousand.

But rather than being surprised by such an attitude on the part of many members of the scientific community, I find it perfectly normal – if perhaps not quite honest; scientists, after all, are people first and scientists second – and thus if they really practiced the scientific “attitude” which they talk about so much, I really would be surprised.

Looked at quite realistically, it seems to be self-evident truth that the world as a whole was in far better shape before we started getting so much “help” from science; and quite frankly, I would not be at all surprised if some scientists exploded the entire North American continent merely in order to measure the noise that such an explosion would make.

So, apart from rare individuals in the scientific community – and you can take it from me that such individuals are as rare as sabre-toothed tigers in the Bronx – there are very few scientists who know anything at all about exercise. But this does not mean that scientific knowledge – to the degree that it relates to this field – cannot be put to good use by people who do know something about exercise, even such people as bicycle mechanics from Ohio or (as in my case) a retired airline pilot and motion picture producer.

Nor is it necessary to “understand” something before making use of it; nobody in their right mind claims to understand gravity but most people have enough common sense to avoid stepping off tall buildings – or, at least they are not surprised by what happens if they do.

And just in order to set the record perfectly straight right from the start, I want it clearly understood that I don’t even claim to understand “anything” about either exercise or muscular function; which puts me in a very advantageous position, since it makes me very aware of my own ignorance – and thus open to new ideas, unafraid of slaughtering any sacred cows.

But it does not follow that I am so stupid that I cannot recognize a self-evident truth when it hits me across the face – even if I can’t explain its most intricate workings. Some years ago I stated that, “... I don’t know how to build anything properly – but I know a lot of ways not to build things.” And while this may be in the realm of “negative knowledge” – it at least prevents me from putting my hand on the same hot fire several times in a row.

Most doctors, and almost all scientists that I have known, are of the sincere, if totally mistaken impression that a man like Bill Pearl was born that way; and while they may admit that exercise may have had “something” to do with his development, they really believe that he would have been much the same, same with or without such exercise. And the mere fact that literally hundreds of thousands of experienced weight trainees are clearly aware that such development is utterly impossible without very hard training makes no impression on science. And while science may label such an attitude as scientific objectivity, I call it utter stupidity.

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For that very reason, after having spent a goodly part of my thirty years in a detailed study of exercise, I was intending to publish the results of my work without taking credit for it under my own name; because, quite frankly, I did not want to connect my name, in the public mind, with as controversial a subject as weight training. Bill Pearl is at least partially – and perhaps primarily – responsible for causing me to change my mind in that regard; he convinced me that failing to take credit for my work would be a mistake; somebody else would then falsely claim any worthwhile results produced.

Now – before too many people rise up in arms – let me be quick to point out that I am fully aware of the fact that there are many very sincere and perfectly honest people in this field; but I do think that they are just as aware of the kooky element in our midst as I am – and I don't think that attempting to deny such a self-evident truth will help matters much.

Thus having stated my position in regard to both science and the science-fakers in this field, I will get down to cases.

You know, and I know, that exercise does cause muscular tissue to respond – and that this response takes the form of increases in size and/or strength. Why this happens is really of no importance – so long as we are able to cause it to happen in a desirable manner.

Thus – for all practical purposes – the only rational approach to the matter is to attempt to determine the most productive method of causing such a favorable (or at least desirable) response, with the least possible expenditure of time and effort and in the shortest elapsed time period.

Apart from health considerations – and this is almost always the case in bodybuilding circles – the desirability of producing great strength and size is not the question; very little of what people do in any field could stand the test of being looked at from a purely practical standpoint – but building an outstanding physique is certainly as acceptable an activity as the far more common habit of permitting the body to become a grossly distorted far caricature of a man.

Thus we find ourselves in the position of trying to choose from among the literally hundreds of methods and systems being touted by various people – usually for their own commercial interest.

Until quite recently there was only one intelligent choice for a man desiring to build great muscular size and/or strength; training with barbells and conventional pulley devices. By comparison to any other method of physical training which preceded their introduction, barbells were literally a great leap forward, a major breakthrough, simply heads and shoulders above any other possible means of training, capable of producing more results in a few months than any other method could produce in a lifetime.

And almost the same sort of comparison could have been made between automobiles and ox-carts; the automobile was “the” method of transportation – until airplanes came along.

And now airplanes have come along in the field of weight training – in the form of the literary revolutionary new Nautilus training equipment.

And what does all of this have to do with the way muscles work? Just everything; because the Nautilus machines are designed with the known functions of muscles clearly in mind – rather than trying to fit muscles to a method of exercise, we have approached the situation from the exactly opposite direction and have tried to fit the exercise method to muscles. We could not redesign human muscular structures – but we could, and did, totally redesign exercise methods.

How? By first asking ourselves exactly what muscles actually do – as opposed to what most people think they do – and then by building machines that were engineered to provide the characteristics needed for inducing muscular response.

Again I hasten to point out that we don't even pretend to understand “why” muscles respond in this fashion; but we do know what is required to produce such a response. For at least several thousand years nobody had any real idea “why” they had to eat – but that didn't prevent them from eating.

Thousands of experiments have clearly shown that exercise produces little or nothing in the way of results if the intensity of effort is low – that is to say, if the work load imposed is so light that the existing level of strength is never taxed; and many thousands of other experiments have just as clearly proven that great intensity of effort produces large scale increases in strength and muscular size.

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Thus it seemed logical that increasing the possible intensity of effort might increase the production of the desired results; but since it was literally impossible to even begin to closely approach the maximum intensity of effort of which muscular structures are capable, while using conventional training equipment, it was necessary to tailor the required equipment to the exact problem at hand.

The “all or nothing” theory of muscular contraction teaches us that individual muscle fibers work all out or not at all; but common sense – or self-evident truth, if you prefer – teaches us a great deal more along those same lines. Since individual muscle fibers work by decreasing their length, by growing shorter, then it is obviously impossible for all of the individual fibers to be contracted (working) unless the body part upon which that particular muscle is exerting its pulling force is moved into a position of full contraction.

And since the “all or nothing” theory also teaches us that only the number of individual muscle fibers that are actually required for a particular load are called into play, then it just as obviously follows that at least two conditions are prerequisites for involving all of the fibers in a particular exercise; first, the muscle must be under an imposed load in its position of full contraction – and, second, the load must be heavy enough to involve the working of all of the fibers in the muscular structure being exercised – but not too heavy, because if it is too heavy then it will be impossible to move such a load into the required position.

An apparently rather dim awareness of some of the above obvious points led, some years ago, to the brief popularity of static forms of exercise; it then being suggested that all that was required was an all-out attempt against an immovable object. And up to a certain point, such thinking was apparently reasonably valid – but unfortunately, several points were totally ignored, or overlooked; a “cold” muscle is incapable of an all-out effort, and again it is not required that we understand why this is true so long as we are aware that it is true – and, secondly, since the trainee is always aware, in any form of static exercise, that actual movement of this type of resistance is literally impossible regardless of the intensity of his efforts, it is unlikely that he will make any sincere effort to work as hard as is required – and third, in the unlikely event that he does exert himself as much as possible, and if it happens that his muscular strength is greater than the strength of his tendon attachments (a not uncommon situation), it is certainly possible for him to literally tear those attachments loose.

To say nothing of the fact that muscles are designed to work by moving – which movement that type of so-called exercise prevents.

However, if some of the characteristics of such static forms of exercise are combined with normal training methods with barbells, then a very significant improvement in results can be produced – and without the danger inherent in static exercise. An amount of resistance should be selected which will permit the performance of at least several repetitions, but then the exercise should be continued to the point of utter failure – to the point that absolutely no movement is possible regardless of the amount of effort expended; in this way, the advantages of both forms of training are derived – and since the maximum, failing effort occurs only after a point of exhaustion has been induced by earlier, lighter repetitions, then there is no danger of hurting yourself – at that point you are not strong enough to hurt yourself.

In the above paragraph, I used the term “lighter repetitions,” and this was not intended to convey the impression that the resistance was lower during those repetitions; merely the fact that such earlier repetitions within a given set of several repetitions would feel light by comparison to the last repetition, since they would be performed at a time when the muscles were fresh and stronger than they would be at the end of the set.

However great an improvement over most forms of training with barbells such a style of training may be – and it really will improve your training progress enormously if you have not been training that way earlier – such training still leaves a great deal to be desired; primarily because, as noted earlier, muscles must be in a position of full contraction before it is even possible for all of the individual fibers to be involved in the exercise – and with almost every single exercise involving the use of conventional pieces of training equipment, there is literally no resistance in that position. And no matter how hard you work a muscle in some other position, you are not involving more than a small percentage of the total number of muscle fibers unless you work a muscle to the point of failure in its position of full contraction.

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Exactly what percentage? Here I must again admit my ignorance; I just don't know – but on the basis of tests conducted using two distinctly different methods for attempting to determine this percentage, it appears that conventional forms of exercise involve only between 14 and 18 percent of the total number of individual muscle fibers, even when the muscle is worked to the point of momentary failure.

What methods were used for attempting to determine this percentage? Well, like the Wright Brothers, who in their ignorance were forced to design and build the first wind tunnel for the purpose of trying to determine the best possible shape for a wing – to say nothing of the fact that two such obvious morons (to quote the scientists of their day) had to think of the idea of the wind tunnel in the first place – I was forced in my ignorance to try to think of a method for myself; and not being limited in my thinking by any knowledge of what was or was not possible or practical, I came up with two rather self-evidently true systems for determining the information I was seeking – methods with an apparently fair degree of accuracy.

Since muscles require oxygen for performing work, it occurred to me that measuring the increase in the amount of oxygen demanded by the body might be interesting; second, since the performance of work creates heat, it also appeared that measuring this heat might tell us something. But, for any sort of comparison, two or more items (or facts) must be available for testing; thus, in this situation, we had to have some other method of exercise to compare to conventional exercise methods.

And eventually we did have such other methods for comparison to previously existing forms of exercise; and when such comparisons were made – and assuming that these new methods were involving 100% of the muscle fibers contained in the muscles being exercised, and it appeared that this was so – then it was obvious that only from 14 to 18 percent of the total muscle fibers were involved in conventional exercises for the same muscular structures, even when such conventional forms of exercise were carried to the point of utter, if momentary, failure, and that a far lower percentage of total number of fibers was involved when such conventional exercises were not carried to the point of failure.

And we measured the amount of horsepower being produced – calculations involving resistance, distance of vertical movement, and the speed of that movement; and we compared the production of results – in the form of measurable strength increases; and we compared the increases of muscular mass – as determined by specific gravity tests; and we...

But why bother to go on; in our ignorance we obviously didn't know what we were doing – it certainly must be purely coincidental that we were producing as much as 46% a week strength increases for as much as four weeks in a row, since most published scientific opinion is on the order of 2% per week.

But in the meantime, some of the people in this part of Florida were getting mighty big, mighty fast – and strong, too; more coincidence, I'm sure.

So we fooled around with this and that, and we tried a lot of things – most of which utterly, and a lot of which things produced little or nothing in the way of significant improvement over other forms of training – and, what with one thing and another, we wasted a good part of our time for nearly thirty years, gaining nothing much apart from lots of “negative knowledge,” a list of things that didn't work, or were impractical, or that didn't justify the effort.

But gradually, we also stumbled on a few things that apparently did work – even if we didn't know why they worked; and, eventually a few points seemed to stand out – things that seemed to be required for producing good results. Without making any attempt to justify – or “prove” – them, I will list these points; they are – one, exercise should be brief – two, infrequent – three, fast – four, carried to the point of momentary failure – five, full range – six, against continuous resistance – seven, against variable resistance – eight, direct, without involving or depending upon other, weaker, muscular structures – nine, balanced to the strength of the muscles in various positions, so that the muscle is worked to its maximum degree in all positions – ten, performed in proper order, thus being an involved point which I will not go into here – eleven, performed in sets of at least six and not usually more than twenty repetitions (but with all sets being carried to the point of failure, regardless of the number of repetitions this requires at this moment).

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Most of the above points are literally impossible when training with conventional equipment – but if as many of them as can be used are incorporated into training programs using conventional equipment, then very high degrees of improvement will result.

But I want it clearly understood that such improvements in training progress seem to be a direct result of the increases in intensity of effort produced by such training; while such training may be – and is – very productive, it is certainly not easy. And primarily for that very reason I think, most trainees simply do not have the willingness to work that hard; while almost all bodybuilders “claim” that they are training very hard – my observations lead me to the exactly opposite conclusion, I think that a bodybuilder that is actually training anywhere near as hard as he could (and as he should for best results) is a rare bird indeed.

But if such training is conducted with the required intensity of effort, then very little training is actually required – and far better results are produced by fewer and shorter workouts in much less elapsed time.

Finally, having discovered the things that were apparently required for producing good results, we still had to develop exercise methods that were capable of providing all of the needed factors in a practical manner.

And what led us into the belief that the previously quoted list of factors actually were required, or that they were all that was needed? Well, unscientific as this approach may be, we had noted repeatedly that leaving out any of those factors reduced the production of results to a marked degree, and that adding other factors either reduced results or produced no apparent increases; and since, at this point in the proceedings, I had no slightest idea of using any of this information in a commercial way – and everybody else who knew anything about the matter simply thought that I was wasting both my time and money – I was not forced by commercial considerations to favor any one approach to the matter, nor was it necessary to jump to any hasty conclusions. In short – I was doing something simply because I was interested in doing so; simply trying to satisfy my own curiosity – which to me is the real scientific approach. And since I didn’t have any committee of “experts” to satisfy – or to “advise” me – I did not, in the end, produce any camels in my attempts to design a race horse. A few monsters, I must admit, but these were such obvious monstrosities that even a poor fool with no scientific background could recognize them; although I must also admit that I usually didn’t recognize them for what they were until after I had built them.

And sometimes I built things that weren’t monsters – and then failed to recognize them for what they really were. In that line, I would like to point out the fact – and it is a fact, and I can prove it – that I built a machine well over ten years ago that had every single one of the required characteristics, and no faults; but, at the time, I not only failed to recognize the machine for what it really was, I then didn’t even bother to test its result producing ability.

Quite recently, upon seeing one of the late model machines for the first time, a former employee of mine remarked, “...but you had a machine like that over ten years ago, I saw it.”

To which I was forced to reply, “Yes, but building something right is not enough; then you must recognize it for what it really is.”

But if this is simply proof of my stupidity, then I am at least not alone in having made such mistakes – nor am I ashamed to admit them; and I did not, at least, rush into production with something that was untested, “hoping for the best,” as a major corporation in this country did a few years ago – which slight error ruined them, bringing a billion dollar corporation to its knees, when their jet transport that was supposed to compete with the 707 and the DC8 failed to live up to expectations, and when they were in such a hurry that they went into production without bothering to build and carefully test a prototype first. Perhaps they had too many scientists on the job – scientists who are probably now looking for jobs, “Shine your shoes, mister?”

So just what did we finally – in spite of all of the blundering – discover in regard to “how do muscles perform work.” Well, we finally noted the simple fact that human muscles don’t perform work directly; instead, they move related body parts, and while the muscles may work in a relatively straight-line fashion, the body parts rotate. This led to the conclusion that a rotary form of resistance was required. But since we are forced to work with resistance provided by gravity – uni-directional (one direction) resistance – this presented quite a problem. Just how do you convert unidirectional resistance into omni-directional (all directional) resistance in a practical manner?

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In effect, we needed a form of resistance that would always directly oppose the movement of the involved body parts – regardless of what direction the body part attempted to move in, the resistance must always be provided in an exactly opposite direction. If the hand moves up, the resistance must be straight down – if the hand moves east, the resistance must be provided towards the west – if the... but that should get the point across.

So you design and build such a machine – even if only two or three hundred failing attempts later; whereupon you immediately discover that it isn't enough – even though it works perfectly, as far as it goes. Because, having such a machine to test, you immediately discover something which was only suspected earlier – muscles are much stronger in some positions than they are in other positions; in practice, human muscles are weaker in their extended positions and strongest (far stronger) in their contracted positions. Which should have been obvious in advance – since the very shape of a muscle makes this apparent; but which, in fact, became apparent only after the fact almost literally hit us across the face.

To make this point clear, I must again rely upon pure supposition – or could it be self-evident truth; apparently the fibers of a muscle that are located near the ends of a muscular structure contract first, then this contraction is a progressive thing, moving towards the center of a muscle from both ends.

Why do I think so? Because apparently no other explanation for clearly observed fact is possible, since muscles are far stronger in their fully contracted positions – and we can prove this beyond any slightest shadow of a doubt – and since this obviously implies that more strands of muscle fibers are being involved in the contraction, then it is unavoidably plain that the center of the muscular structure, the thickest part of the structure, the area where more strands of the fibers are located, is involved in the work only in a position of full contraction. If the work of these centrally located fibers could be called upon in an extended position, then the muscle would not be weaker in such an extended position – but it is weaker when extended, far weaker, so it logically follows that involving all of the fibers in the contraction is impossible in any position except a position of full contraction.

So at that point in our work, it became obvious that providing rotary forms of omni-directional resistance was not enough by itself – although it was a long first step in the right direction; additionally, it was then apparent, we had to provide variation of resistance – a form of resistance that would actually change during the performance of the exercise movements. To a slight degree, spring-type exercise devices are better than other conventional forms of exercise for the very reason that they do provide variable resistance, resistance that increases as the movement progresses; but unfortunately, springs do not increase their tension at the same rate that human muscles increase their strength as they move from an extended position to a contracted position.

Second, although it was obvious that muscles do increase their strength as they contract – it was far from obvious just “how much” this increase amounted to, or at exactly which point in the movement that the increase in strength occurred, or at what rate it was produced.

Third, since nobody – but NOBODY – had ever trained on a type of exercise device that provided the exactly right sort of resistance, it was also apparent that we could not determine the required information by measuring the strength curves of people who had been training by conventional methods; rather than giving us the needed information, such data would have been extremely misleading – if we had been foolish enough to rely upon it. But that was such an obvious trap that even a stupid fellow like I am did not fall into it.

Because a man that had been training with conventional methods would certainly be a product of such training methods; that is to say, he would be overdeveloped in some areas in proportion to other areas – since some areas would be worked very hard by conventional training methods, and some areas would not be worked at all. In fact, when we did test the strength curves of such individuals – men who had been training heavily with conventional methods – we found exactly what we expected to find; in the positions where they should have been strongest, they were actually weakest. We expected such a result because we had long noted that conventional training methods provide very little if any resistance in the fully flexed positions – most exercises actually provide literally no resistance in that position; at the very point where most resistance is required, none is provided.

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But if you can't obtain the information required regarding proper strength curves by testing individuals that have been training by conventional methods, or even by testing people that have never trained at all, then just where do you get such information – with the obvious assurance that it is correct information?

Well, I will leave that up to the individual reader to figure out for himself; if, at this point, that isn't perfectly obvious – then you probably don't understand any of the rest of this either. But I will give you a hint; you will find such people in hospitals, or old-folks homes. Remember, while exercise produces increases in the size and strength of muscles – it is also true that a lack of exercise produces the opposite result. And while incorrect exercise may – and will – produce unbalanced development, a lack of any exercise will eventually result in a very low level of strength, but a perfectly balanced strength curve. Or so it appeared – and in fact, so it turned out; since I was not content to base my conclusions on a single bit of evidence, I searched for other proof for cross-checking purposes. And in this regard, I was fortunate in having several doctors in the family – since people were beginning to get suspicious about me hanging around cemeteries in the middle of the night.

What sort of proof? Oh, things like the cross-sectional areas of muscular structures – and the relationship between the area of a muscle in its middle and toward its end.

Then, too, finding the rate at which a particular muscular structure changed its position from one of full extension to one of full contraction wasn't enough by itself; because most bodily movements are compound movements – caused by more than one muscular structure. Thus the strength of one particular muscle might be increasing rapidly at the very time that total strength in a given movement was actually decreasing; and in fact, this happens to some degree in almost all exercise movements. It happens because the movement progresses to a point where assistance provided by one or more muscular structures is no longer available.

So, obviously, providing the proper rate of increase in resistance was not quite as simple as it might have appeared at first – knowing the rate at which various muscles increase their strength levels as they contract was not enough.

We also had to determine the exact contributions of each of several closely interrelated muscular structures; at exactly what point in the movements did these assisting muscles come into play, how great was their contribution, at what point did they cease to render assistance, and so on, and on, and on...

And do I now claim to be in possession of all the final answers to all of these extremely complex questions? Don't be ridiculous; I am only too aware of my ignorance, but at least I'm aware that such questions are important, and I do have at least a few hundred times as much information on these subjects as everybody else put together, including all of the scientists on planet Earth, none of whom that I have ever heard of seem to be even aware that such questions exist. Or, if they do have such an awareness, they have certainly been mighty quiet about it – and by and large, scientists may be a lot of things, but they are seldom very quiet about their claimed knowledge.

But in the meantime, with or without the “final” answers, we have been able to come up with simply enormous increases in the production of results. How enormous? Well consider the following points...

1. If you can produce the same degree of results (as that previously being produced by conventional training methods) in half of the previously-elapsed time, then you have improved your rate of progress by 100% - doubled your production of results.
2. And if you can do so while performing only half as many workouts as were previously required, then you have improved your previous rate of progress by 300% – quadrupled your production of results.
3. And if these fewer workouts can be performed in only half of the time that you were devoting to each of your former workouts, then you have improved your rate of progress by 700% – octupled your production of results.
4. And if – instead of just producing the same degree of results you were producing earlier – you can produce 25% more in the way of muscular mass and/or strength increases, then you have increased your rate of progress by 900% – you will be producing results ten times as fast as you were by conventional methods of training.

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5. Impossible? When training with conventional methods, yes – utterly out of the question; but when training all of your muscular mass – as opposed to training only a small part of it – then such production of results becomes not only possible but expected.
6. And in many cases, increases in rates of progress over those produced by conventional methods of training have actually exceeded 3000%.
7. In one instance, after more than four years of hard, steady training with conventional methods – continuous training right up to two days prior to the start of his training with the then experimental Nautilus training equipment – one subject increased his accurately measured strength levels a minimum of 33.3% in the least effected area and a maximum of 184% in the area where the best results were produced, in exactly twenty-eight days, as a result of eleven fairly brief workouts.
8. Another trainee working with the above mentioned subject did almost equally as well – and in some areas, better.
9. Can any trainee using this equipment produce the same results? Obviously not; the exact production of results will depend to a great degree upon the individual potential of the subject – but the rate of progress should show a very similar degree of improvement when compared to the same subject's rate of progress experienced with other methods of training. If the subject is willing to work as hard as the above mentioned trainees did.
10. And what would happen if such productive methods were used as often and/or as long as conventional methods are normally used? Progress would be brought to a halt – or actual losses would occur; because the recovery ability of the body would be exhausted beyond its ability to recuperate between workouts. Thus – brief, infrequent workouts are not only a possibility, but are a distinct requirement for the production of the best possible results. “If some exercise is good, more is better” is certainly not true in this instance.

So there you have it – unscientific perhaps, and certainly far from being the final answer, but obviously self-evident truth as far as it goes; which just happens to be a great deal farther – and a lot faster than anything else in the field.

And two or three years from now, when we have had a bit more time to work with a few individuals with better than average potential, and when we have produced a few muscular measurements that are really as big as some bodybuilders claim today, then I want to hear some scientific type try to tell a poor fool such as myself that “... he was born that way.” Maybe so, but if so, his daddy was a gorilla.