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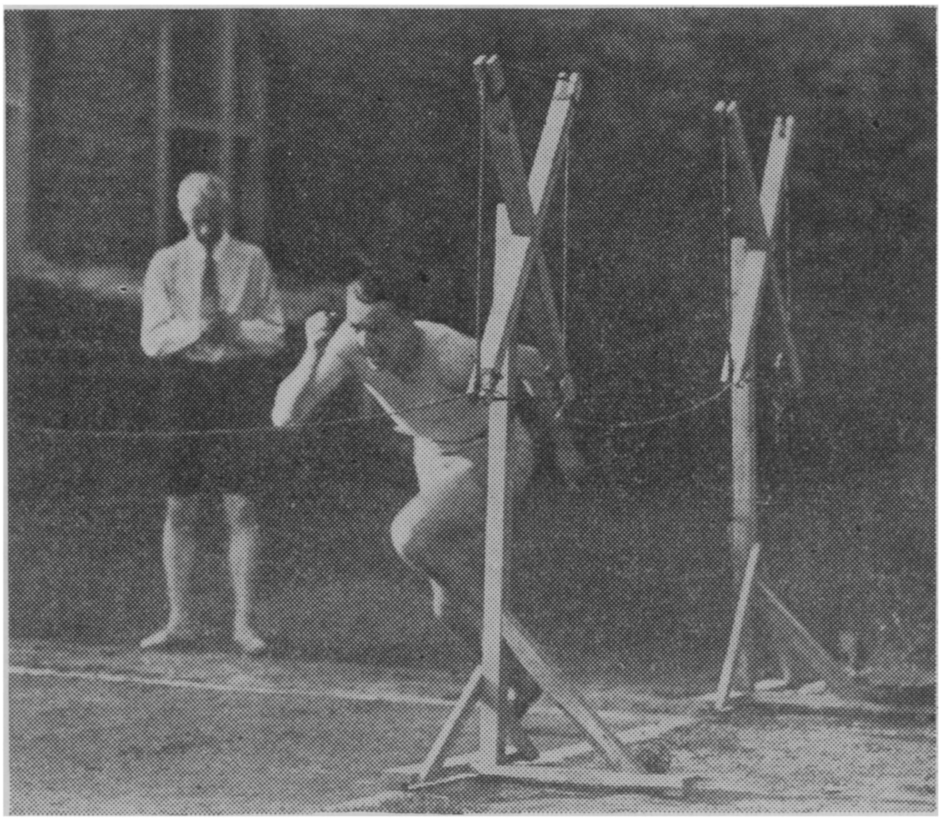
PHYSIOLOGY

Science Now Helps Train Winning Athletes

By Haldane Gee

Track men can now predict their probable chances of breaking records. Henceforward, sprinters who win will not merely be in "good form," nor those who fail, simply in "poor form." Coaches will no longer view the star performer of the meet with reverence as an inspired creature, or one part greyhound for the occasion. Instead they will be checking back impersonally on tables of figures and sheets of diagrams, to find out what the overvoltage was that gave the extra driving power to the human motor, or how the friction factor fell and permitted a higher speed from the same energy. Becoming assistant physiologists for the winter, the coaching staff will be provided with advance dope based on the results of refined research in a new running track laboratory, and they know where to expect the breaks.

The genius behind this application of science to athletics is Dr. A. V. Hill, physiologist of University College, London, and research professor of the Royal Society, who for the time being is visiting lecturer in chemistry at Cornell University, and himself an athlete. Dr. Hill's special field in experimental biology has to do with muscular exercise. For years he has been studying the physical processes and the chemical reactions which go on in contracting, fatigued and recovering muscle; the nature of the impulses sent along the nerves which bring the muscle into play; the mechanical work which the human engine can produce from the fuel it eats; and how the breathing, and circulation of the blood set the drafts and flues for burning that fuel. In 1922, one of the highest possible forms of recognition that can come to a scientist was accorded him when he was given a Nobel prize in medicine.



C. M. WESLY, captain of the Cornell track team, starting on a run by the coils.

Heretofore laboratory experiments have furnished most of the information which Dr. Hill is seeking. To study fatigue in muscle, he and his friends turn chemists and analyze animal tissues for their lactic acid load. Busy with nerve impulses, they become physicists and measure the infinitesimal rise in temperature which occurs in a nerve thread when a signal passes along it. Some of the data have been obtained by following the respiration of dogs and other animals (even cockroaches) kept in chambers which permit analyzing the air breathed in and out, and in this way the extent and nature of chemical change in the animal's body is revealed. Other tests are made on men running up and down stairs and riding stationary bicycles.

Again, much has been gleaned from the published statistics on sport and racing. These records, Dr. Hill points out, are really reports of experiments on muscular exertion. By a scientific study of them he has not only supplemented his laboratory work with figures for maximum work and effort for human beings, but he has also discovered relationships of value to both athletes and their trainers in preparing for future contests. The tests on the Cornell athletes are an extension of this line of attack. With the stadium facilities of the university at his disposal and cooperating with the coaches, Dr. Hill has been able to

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show that the speed of short distance runners is governed by two measurable factors. Sprinters were selected because previous work had already dealt with the limiting factors in long-distance running.

Ordinarily the only record kept for sprints is the elapsed time in which the distance is covered. While this gives the average speed of the runner over the whole stretch, it tells nothing about the rate of "pick up" or acceleration. Dr. Hill wanted to know this, so he fitted up his running track with an electrical device analogous to that used for measuring the muzzle velocity of shells during the war. At intervals along and parallel to the cinder path he set up coils of wire of 200 turns, connected to a sensitive galvanometer which recorded the tiniest currents on a drum run by an electric motor and placed in a nearby room. The athlete under test carried a small magnetized strip of steel tied round his waist which induced a current in each of the coils as he flashed past—an adaptation of the old observation in electricity and the principle of the dynamo, that a magnet waved near a closed coil produces a current. The devices used were so sensitive that they gave the runner's time of arrival at each coil to within one two-hundredth of a second. The time of the starting signal was registered with equal precision. Dr. Hill used ten coils, spaced closer at the start and more widely the rest of the way, to get the exact fractions of time in which each part of a 60, 100, 150 or 200 yard run could be covered.

Like Falling Raindrop

The figures showed that the sprinter's speed increased rapidly in the first few yards, and continued to increase up to about 30 yards; then it kept uniform, at presumably the high-

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News-Letter Features

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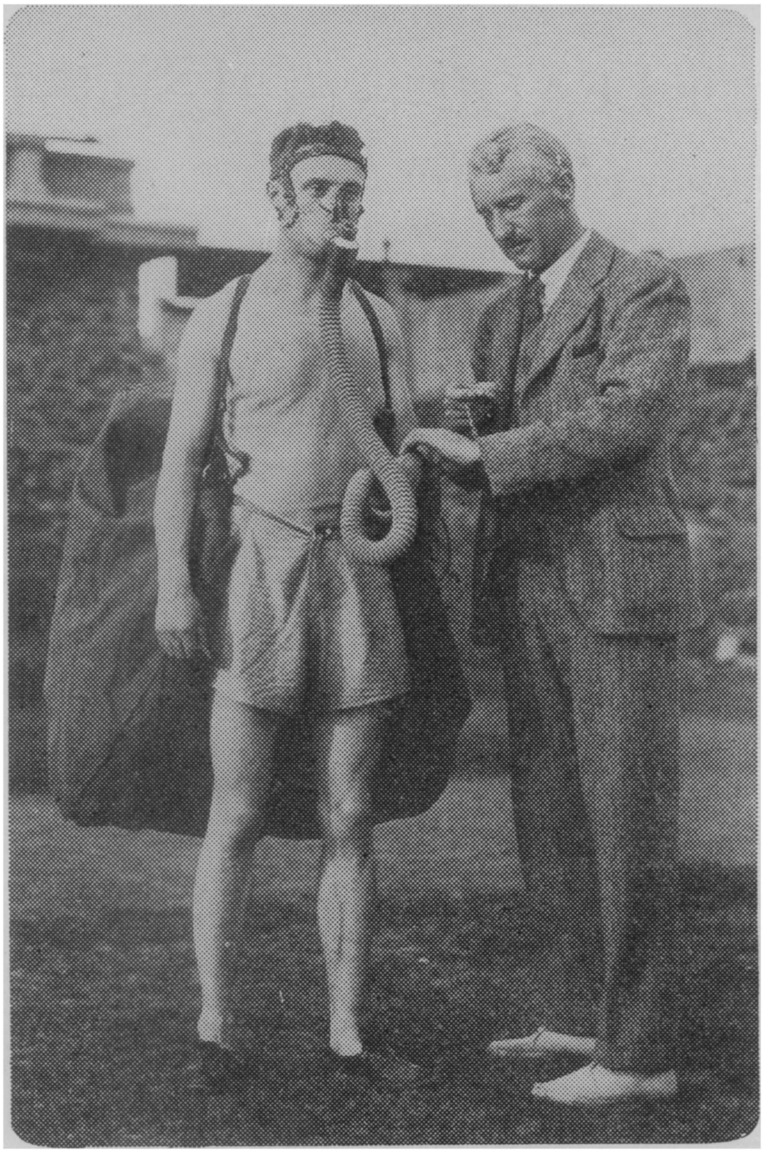

PROF. HILL TAKES THE PULSE of an athlete after running. As he runs he breathes into the bag on his back, and by analyzing the air, to determine dioxide in it, the scientist can measure the rate at which the runner used up his energy.

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est speed of which he was capable. This verified Dr. Hill's expectation of the nature of the forces at work. His graphs were of just the same shape as those for the speed of a falling raindrop, which sinks faster and faster until it attains a constant speed at which the force of gravity on the drop is just equal to the resistance encountered.

"In the case of a sprinter the mechanics are the same," said Dr. Hill in propounding his theory of the short-distance race before fatigue sets in. "He exerts a constant force throughout the race, and is opposed by the friction of his body, which strictly speaking, is the viscosity of his muscles." Working on this assumption and using simple laws of physics, the physiologist proceeded to fit to the formula the observed times at which each of the coils on the track was reached. The calculated times checked with those observed to within a hundredth of a second, he found. This means that air resistance is a comparatively unimportant fraction of the whole, and that governing a runner's speed are the two balancing forces of the effort he exerts, which is constant, and the opposition he gets from his muscles, which is proportional to his speed. Both factors can be expressed in figures, and they are approximately constant for any one athlete, but different for different athletes. Considered together, the pair of figures are an exact index of a sprinter's performance and an analysis of his success.

What the Sprinter Needs

"The man who exerts but little driving power and possesses muscles with high friction will never make a sprinter," Dr. Hill explained. "Good runners should have either a high driving force or muscles operating with low viscosity. The man who has both will make the best showing of all."

Using the refined clocking method, candidates for a sprinting team can be sorted out on the basis of their grades with respect to each of these two measurable quantities, as expressed by numbers.

Dr. Hill has found that he can propel himself down the track with a force amounting to something over half of his body weight. A good sprinter may drive himself with an effort equal to 90 per cent. or even more of the weight of his body, it has been found. This amounts in the case of a 140 pound man, who can do the 100 yard dash in 10 seconds flat, to a work rate of seven horse-power, and involves as much energy as if he were shooting himself vertically into the air, with frictionless muscles, *at almost the same rate that* he goes horizontally along the ground!

To cope with such excessive power-demands as this, nature has arranged emergency chemical processes in the body which can be overloaded for a short time without ill effects. During excessively violent muscular effort, the glycogen, or animal starch of the body, is converted into lactic acid, permitting the release of huge quantities of energy. This, the same acid as that found in sour milk, is responsible for the sensation of fatigue as it accumulates. It is removed again with the oxygen the panting runner takes in when he sinks down to rest. "A man can go into debt for oxygen in this way to the extent of 15 quarts in a long race," said Dr. Hill. "After a 100 yard sprint a good performer requires at least five quarts of oxygen before the lactic acid, more than an ounce of it, has been cleared from the muscles.

Oxygen the Secret

"Speed in a middle distance run is determined by the amount of the oxygen debt a man can incur, and also by the amount he can take on as he goes along. Even the best athletes can take on only four quarts of oxygen a minute, so they soon go into debt, and when they get behind to the extent of the full 15 quarts, they are incapable of further effort. A runner's

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record times for the different middle distances can be correlated closely with his rate of intake of oxygen and the limit of his oxygen debt."

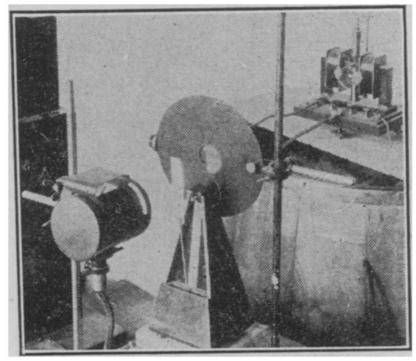
Dr. Hill's earlier researches into the science of athletics show that simple physiological experiments provide an explanation of the cardinal rules which coaches have laid down by long experience as the fundamentals for various track events. In discussing them, the scientist said: "In the case of human muscular movement, we find experimentally that about one movement a second with full force is cheapest. Rowers, by experience and from tradition, adopt just this speed of swing. Now we know why.

"To get the highest average speed out of a given store of energy, a runner should not save himself for a sprint finish, for adding 5 per cent. to the speed requires the expenditure of 20 per cent. more energy. It may be well to start rather fast, in order to force the body to a high working rate early in the race: otherwise a uniform speed throughout is best."

Broad Jumpers Go High

By timing jumpers, Professor Hill has found that all the complicated, violent movements of a high or broad jump are gone through in less than a second. Calculating from the time they are off the ground, record broad jumpers execute a creditable high jump as well. One must jump high to jump far.

Recent advances in the physiology of exercise and nutrition indicate what diets are most advisable in long distance performances. Sugar, the most readily available form of energy for the body furnace, should be taken on before demands are made on fat, the less easily used foodstuff, it has been shown.



THE ELECTRICAL TIMER, which is set up in a room near the track. It records the electrical impulses from the coils of wire along the track as the runner goes by with a piece of magnetized steel on his belt.

Ultimately the researches may be extended to horse and whippet racing; and to rowing and bicycle contests. Other points the physiologists may explain are the influence of the suprarenal glands during a keen contest, which by secreting their potent juice at an abnormal rate into the blood stream, may whip up the body processes to a considerable extent.

Of scientific sport for its own sake, Dr. Hill expressed himself recently as follows: "The practice of athletics is both a science and an art, and just as art and science are the most potent ties tending to draw men together in a world of industrial competition, so sport and athletics, by urging men to friendly rivalry, may help to avert the bitterness resulting from less peaceful struggles. If, therefore, physiology can aid in the development of athletics as a science and an art, I think it will deserve well of mankind."

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HOW A RUNNER PICKS UP SPEED

Prof. Hill's results show that in a 60-yard run, an athlete can go

1 yard	**in**	**.56**	**seconds**
3 yards	**in**	**.97**	**seconds**
6 yards	**in**	**1.44**	**seconds**
10 yards	**in**	**1.98**	**seconds**
15 yards	**in**	**2.56**	**seconds**
20 yards	**in**	**3.12**	**seconds**
30 yards	**in**	**4.16**	**seconds**
40 yards	**in**	**5.18**	**seconds**
50 yards	**in**	**6.18**	**seconds**
60 yards	**in**	**7.20**	**seconds**

After the runner has gone about 30 yards, his speed becomes uniform.

In the southern hemisphere the shadow on a sun dial travels counterclockwise. As the hands of the earliest clocks moved in the direction of a sun dial shadow, our modern clocks would have hands moving from right to left if they had been first made in the southern hemisphere.

Whale meat tastes very much like beef.

Nero spent $150,000 on flowers for one banquet.

Fish are sometimes paralyzed by lightning for several days.

New tires for big English airplanes weigh 200 pounds each.