

# Anti-doping, the next essential steps

Yannis P. Pitsiladis, MMedSci, PhD, FACSM

University of Brighton  
United Kingdom

# 2012 Summer Olympics



2012 International Olympic Committee


# Russia's state-sponsored doping system

## Achievements and titles

Personal best(s) 800 m: 1:55.87 (2011)

## Medal record

### Women's athletics

Representing  **Russia**

### Olympic Games

 2012 London 800 m

### World Championships

 2011 Daegu 800 m

 2013 Moscow 800 m

### European Championships

 2010 Barcelona 800 m

### World Indoor Championships

 2010 Doha 800 m

### European Indoor Championships

 2009 Turin 800 m



# Russia's state-sponsored doping system



(voice dubbed)

That is our system and in Russia that works only with pharma...

My coach fortunately works with Melnikov [*Russian Head Coach*] and he helps to cover up the tests. They allow him to change the dates for the controls.

Oxandrolone [*anabolic-androgenic steroid*] is very quickly out of my body again. It takes less than 20 days. We have tested that.

My husband has very good contacts to the doping control laboratory.

# SPORT

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## Russian doping: McLaren report says more than 1,000 athletes implicated

9 December 2016 Sport

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The report's author, Richard McLaren (centre), said doping took place on 'an unprecedented scale'

**“The Russian Olympic team corrupted the London Games 2012 on an unprecedented scale, the extent of which will probably never be fully established... The desire to win medals superseded their collective moral and ethical compass and Olympic values of fair play.”**

# Make Sport Great Again: The Use and Abuse of the Therapeutic Use Exemptions Process

Yannis Pitsiladis, MMedSci, PhD, FACSM<sup>1,2,3</sup>; Guan Wang, PhD<sup>1,2</sup>; Alain Lacoste, MD<sup>3,4</sup>; Christian Schneider, MD<sup>3,5,6</sup>; Angela D. Smith, MD, FACSM<sup>3,7,8</sup>; Alessia Di Gianfrancesco, PharmD, PhD<sup>2,6</sup>; and Fabio Pigozzi, MD, PhD<sup>2,3</sup>



**Figure:** The impact (gold, silver, bronze, and diploma) of the final medal tally of the updated retesting of samples from Beijing ( $n = 1053$ ) and London ( $n = 403$ ).

# Prevalence of Blood Doping in Samples Collected from Elite Track and Field Athletes

Pierre-Edouard Sottas,<sup>1\*</sup> Neil Robinson,<sup>1</sup> Giuseppe Fischetto,<sup>2</sup> Gabriel Dollé,<sup>2</sup>  
Juan Manuel Alonso,<sup>2</sup> and Martial Saugy<sup>1</sup>

	n <sup>a</sup>	Prevalence M1, % <sup>b</sup>	Prevalence M2, %
Males	4028	12 (10–15)	12 (10–15)
Country A	205	48 (35–63)	78 (54–99)
Country B	352	3 (1–11)	1 (0–2)
Country C	257	23 (15–30)	28 (17–36)
Country D	208	6 (3–19)	5 (0–17)
Country E	160	18 (11–30)	18 (7–28)
Country F	148	6 (1–25)	2 (0–22)
Country H	160	39 (20–54)	51 (21–87)

<sup>a</sup> n, Number of samples from which the estimates were derived. Prevalence M1, minimal estimates without any assumptions on the doping method. Prevalence M2, estimates obtained assuming doping with rEPO micro-doses.

<sup>b</sup> 95% CI estimated by bootstrapping methods, with any negative estimates rounded toward 0%.

**Table 2. Period prevalence estimates of abnormal blood profiles in elite track and field athletes.**

Females	3261	18 (15–21)	18 (15–21)
Country A	445	46 (35–58)	50 (35–68)
Country B	130	8 (4–34)	2 (0–11)
Country C	147	12 (4–20)	14 (1–28)
Country D	103	1 (0–11)	0 (0–3)
Country E	106	11 (7–20)	8 (1–14)
Country F	110	6 (3–19)	0 (0–13)
Country H	65	36 (13–62)	36 (5–66)
All	7289	14 (12–16)	14 (12–16)
All nonendurance	1329	3 (0–8)	1 (0–3)
All endurance	4999	18 (15–22)	19 (16–22)

# Sport in crisis

## Rio Olympics 2016: Anti-doping system needs complete reform - Thomas Bach

🕒 2 August 2016 | Olympics

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Bach claimed a total ban went against "natural justice" for clean Russian athletes

# A Holistic Antidoping Approach for a Fairer Future for Sport

## FIMS: INTERNATIONAL PERSPECTIVES

Yannis Pitsiladis, MMedSci, PhD, FACSM<sup>1,2,3</sup>; Ivo Ferriani, BSc<sup>2,4,5</sup>; Michael Geistlinger, PhD, Jur<sup>3,6</sup>; Olivier de Hon, PhD<sup>7</sup>; Andrew Bosch, PhD<sup>8</sup>; and Fabio Pigozzi, MD, PhD<sup>2,3,9</sup>

### The Problem: Inefficiency of Antidoping Process

There is no doubt that sport, as a credible brand, is in crisis. The magnitude of the problem is well illustrated with a brief description of three lines of evidence in recent years that demonstrate, in the words of David Howman, former director general of the World Anti-Doping Agency (WADA), "We are catching the dopey dopers, but not the sophisticated ones" (6). The first line of evidence is the exposure of the cyclist Lance Armstrong as a drug cheat. The evidence now shows that the U.S. Postal Service Pro Cycling Team ran, what some consider, the most sophisticated, professionalized, and successful doping program that sport has ever seen (11). Despite being tested about 275 times in his cycling career, Lance Armstrong never failed a doping test and was only exposed by the testimonies of some of his coconspirators. A look at the prohibited methods and substances the cyclist admittedly abused include blood transfusion, erythropoietin (EPO), growth hormone, cortisol and testosterone, and testify to an antidoping problem in terms of detection of these traditional doping methods and substances. It is important to point out that the Lance Armstrong case predates many of the more positive recent antidoping developments associated with the new World Anti-Doping Code (WADC) (14), such as improved intelligence and smarter testing (e.g., Athlete Biological Passport [ABP]).

The second line of suggestive evidence is the appearance of systematic and state-colluded doping in Russia; the events of which have been summarized recently (7). Briefly, an ever-increasing body of evidence is emerging which indicates that there may have been a systematic state-sponsored

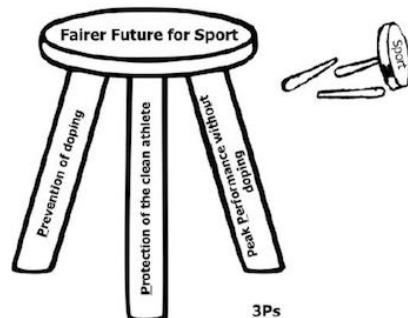


Figure: A holistic antidoping approach.

currently discussed new Independent Testing Authority (ITA) that is expected to be operational before the Pyeongchang Winter Olympics in 2018. The startup costs for the ITA are being met by the International Olympic Committee (IOC), whereas running costs are expected from money generated on a pay-as-you-go basis from testing for International Sports Federations (IF) and major event organizers. However, it remains to be determined how many IF will use the ITA's testing services should its use be nonmandatory.

This evolution of the antidoping process requires "out of the box" thinking. For example, a solution that encompasses a holistic antidoping approach comprising of at least three primary antidoping pillars or 3Ps (see Figure) motivated by the need to prevent doping, protect the clean athlete, and promote performance without doping. The WADC (14), which came into effect in 2003, as well as the subsequent code amendments, which came into effect in 2009, but especially in 2015, is a key development that underpins the first two 3Ps, prevent doping and protect the clean athlete. New features of the Code allow antidoping authorities to test intelligently, retest smartly (i.e., samples stored for 10 yr), work collaboratively, and impose quick and greater sanctions. This modernization process also must support state-of-the-art research that aims to develop more effective next-generation antidoping tests that may possibly have the capacity, in the near future, to allow antidoping authorities to impose greater sanctions — up to lifetime bans where there is indisputable evidence of long-term benefits from doping (e.g., muscle memory [2]). There has been significant investment from WADA and other sources (e.g., the IOC) to develop the next-generation antidoping tests involving "omics" methods (i.e., genomics, transcriptomics, metabolomics, and proteomics) with improved discriminatory power relative to current detection protocols. Recent studies from numerous laboratories have confirmed the potential of transcriptomic microarrays, which can reveal distinct changes in gene expression after blood manipulations, to enhance the ABP (15). There is, therefore, a pressing need to intensify research efforts that involve such state-of-the-art technologies to identify new

and even more robust molecular signatures of doping that can be used in combination with the ABP or the steroidal module and, intriguingly, even as a stand-alone test. In the future, this approach also could significantly impact the antidoping obligations of athletes, such as the "athletes' whereabouts."

Equally, this modernization process must embrace peak performance development of all forms that do not violate antidoping rules and/or the rules of the sport; the third of the 3Ps, promote performance without doping. Modern-day sport also is big business — no longer an amateur pastime for the privileged few but a vocation for thousands of athletes and their extensive entourage of physiologists, nutritionists, biomechanists, psychologists, and the like. A recent example of this third pillar is the Sub2 marathon project (www.sub2hrs.com) (15). The Sub2 project is the first dedicated international research initiative made up of specialist multidisciplinary scientists from academia, elite athletes, and strategic industry partners with the aim to promote high-performance marathon running without doping. As such, all athletes participating in the Sub2 pro-

heart rate and speed distance or stride sensors or similar devices worn by athletes during an event, provided that any such device cannot be used to communicate with any other person. Such technological advances to improve athletic performance are historically considered to be ethical, and as such, they are acclaimed and considered to be part of the lore of Athletics. The problem of course is that a spectator from the outside does not know when a world record is being broken or how much of the record is due to the athlete or due to other factors. This is where science can help, in quantifying the effects of these different factors. Antidoping science in particular is necessary to maximize the confidence that can be given to the public that a particular athletic feat is indeed performed without the aid of prohibited substances or methods.

### Concluding Remarks

The high-profile doping cases, such as Lance Armstrong and Russia clearly demonstrate, albeit indirectly, the inadequacies of the antidoping process. That is not to say that there has not been significant progress in the fight for clean sport since the very dark days for sport in the 1980s and 1990s. The Russian scandal is rather unique, regressing sport back to the days of the likes of East Germany, and almost no amount of regulation could have easily prevented its occurrence; this unprecedented case provides a unique opportunity for vital lessons to be learned moving forward. There is, therefore, an urgent need for "out of the box" thinking to continue to make improvements to secure a fairer future for sport. A unique solution is proposed here that encompasses a holistic antidoping approach comprising of at least three primary antidoping pillars or 3Ps motivated by the need to prevent doping, protect the clean athlete, and promote performance without doping. This holistic antidoping approach exemplifies a more modern and fit-for-purpose antidoping philosophy, one that is evidence-based, acknowledges, and celebrates diversity in natural athletic talent and training environments with differing access to sponsorship, support teams, and technology. To rebrand and restore the credibility of sport, it is essential that all must play by the same rules so that everyone has a chance to succeed — albeit not an equal chance. This is the true essence of sport.

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# A Holistic Antidoping Approach for a Fairer Future for Sport

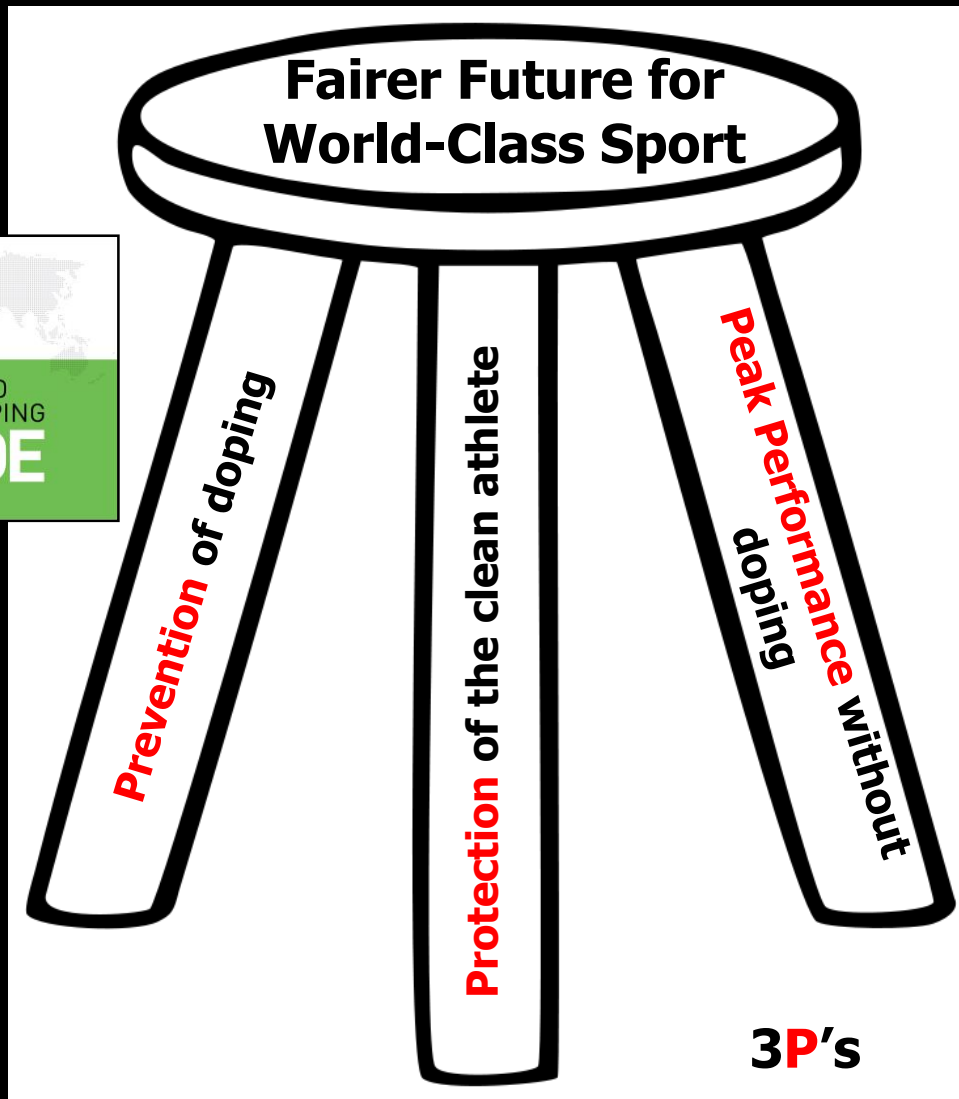
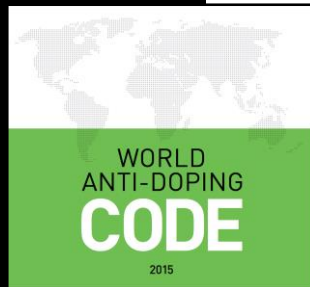
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July/August 2017 - Volume 16 - Issue 4



# Deterrent effect of sample storage for 10 years



**WADA CODE 2015**

# Intelligent Testing

Wouter  
Smak



## TECHNICAL REPORT

*International Journal of Sports Physiology and Performance*, 2009, 4, 129-133  
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### **Performance Profiling: A Role for Sport Science in the Fight Against Doping?**

**Yorck Olaf Schumacher and Torben Pottgiesser**

“A new approach could involve monitoring the rate of improvements in competition performance of an athlete from an early age, in combination with monitoring of blood values or steroid profiles once an appropriate level of competition is reached. Although sudden increases of performance can be induced by many reasons other than doping (improved training strategies, nutrition, growth in young athletes, etc), such observations are nevertheless worthwhile to trigger target testing of the athlete. In connection with data from blood and/or urine profiling, such “performance profiling” might improve the identification of suspicious athletes’ behaviors. In a similar context, mathematical analyses of winning patterns of gamblers are used with success to identify cheaters in casinos”

# Acute Topics in Anti-Doping

Editors

**O. Rabin**

**Y. Pitsiladis**



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Medicine and Sport Science, Vol. 62

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Editors: **Rabin, O.** (Montreal, Que.);

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A comprehensive update on anti-doping –  
from legal issues to science

# Acute Topics in Anti-Doping

Editors: **Olivier Rabin**

**Yannis Pitsiladis**

Doping represents the dark side of amateur and professional sports – in order to protect athletes around the globe, anti-doping rules are continuously revised and improved. This publication reviews the current regulatory framework, scientific aspects, future approaches, and social and ethical dimensions of the fight against doping in sports. Prominent experts on the implementation of anti-doping strategies, as well as leading researchers in science and medicine, have contributed to this publication. In keeping with its interdisciplinary origin, the book is intended for athletes, coaches, students, scientists, anti-doping officials, and all others interested in anti-doping and sports. Ranging from legal and educational to scientific and medical issues, this collection emphasizes the need for a multidisciplinary approach and the importance of preventative strategies in the fight against doping in sports.

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# Acute Topics in Anti-Doping

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# A Holistic Antidoping Approach for a Fairer Future for Sport

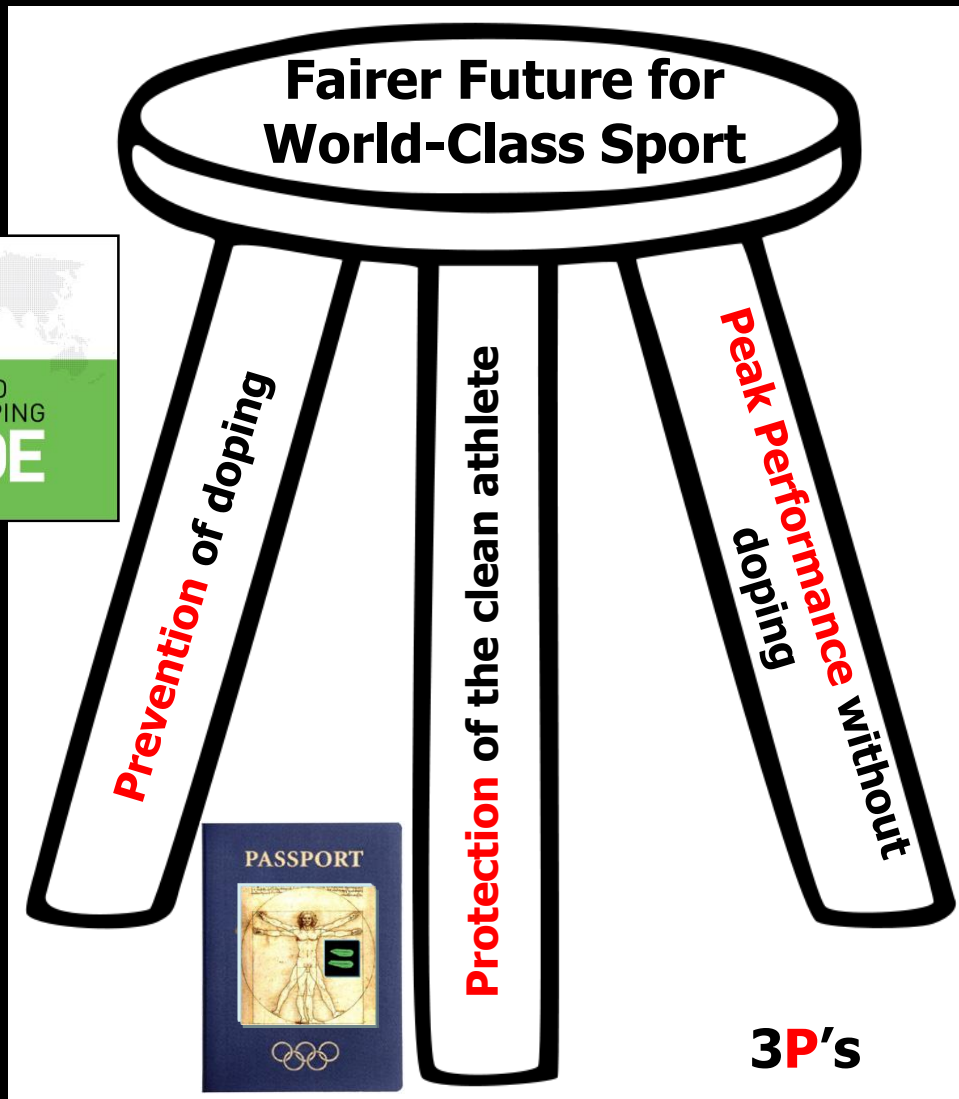
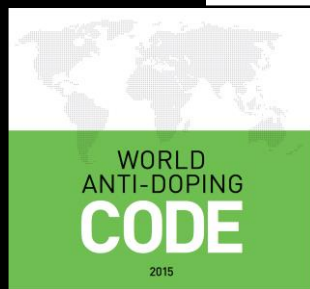
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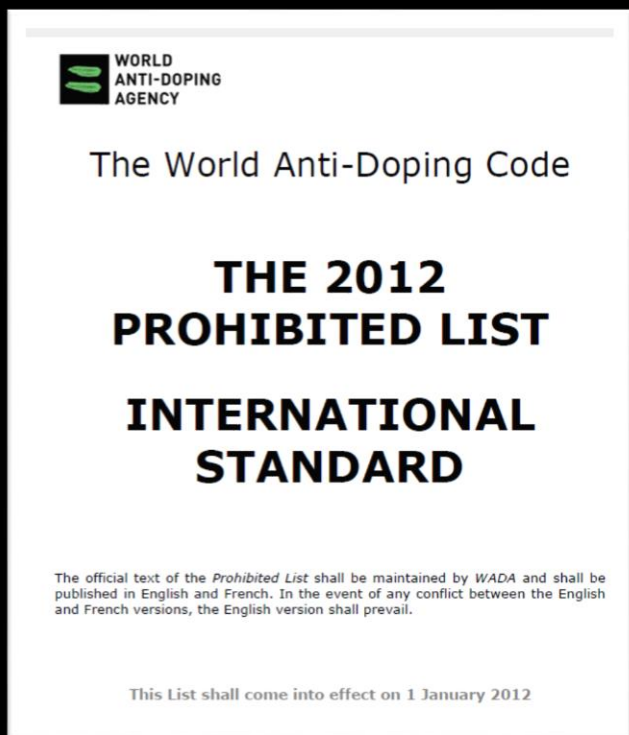
July/August 2017 - Volume 16 - Issue 4



# The Problem



*Despite more than 250,000 tests being carried out in the last year, only 36 came back as positive for EPO.*

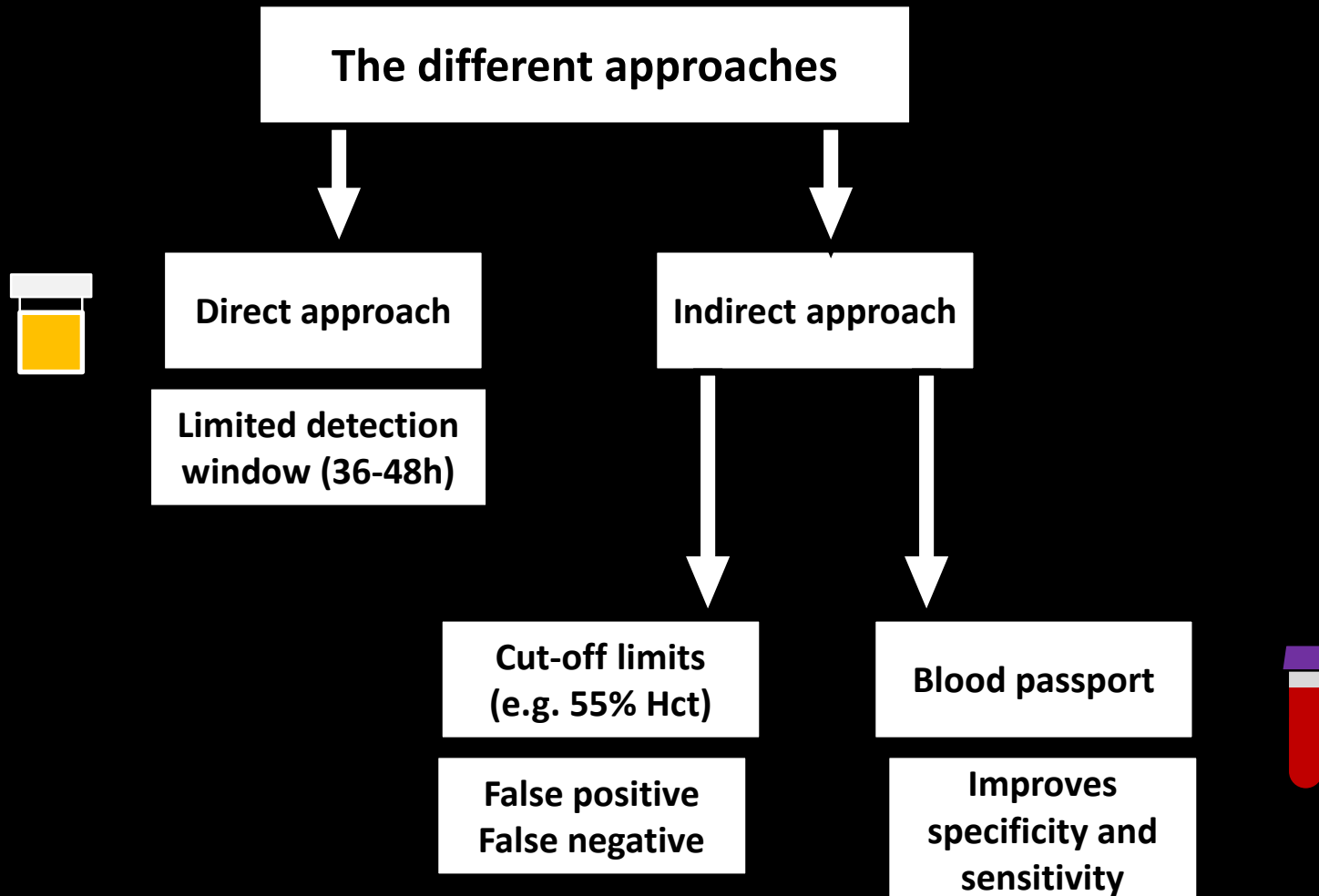


*“We are catching the dopey dopers, but not the sophisticated ones”.*



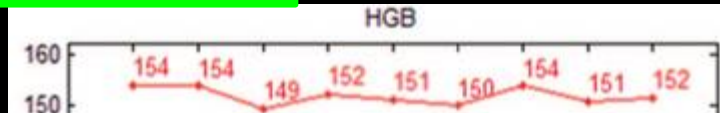
David Howman  
director general of the WADA

# Blood Doping Tests

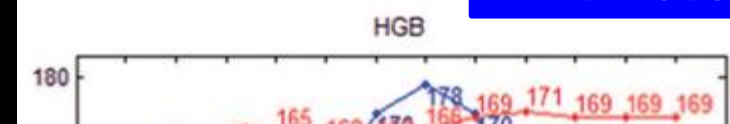


# Athlete Biological Passport

**Athlete A**



**Athlete B**



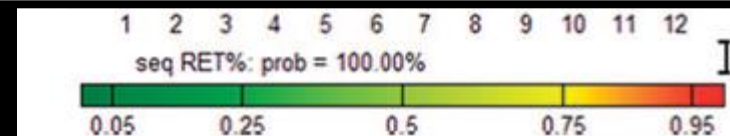
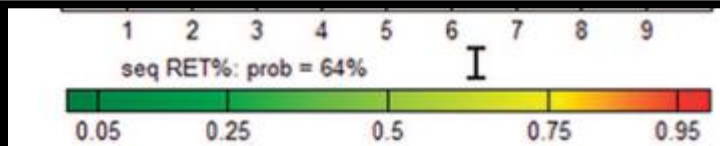
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DOI 10.1007/s00421-011-1867-6

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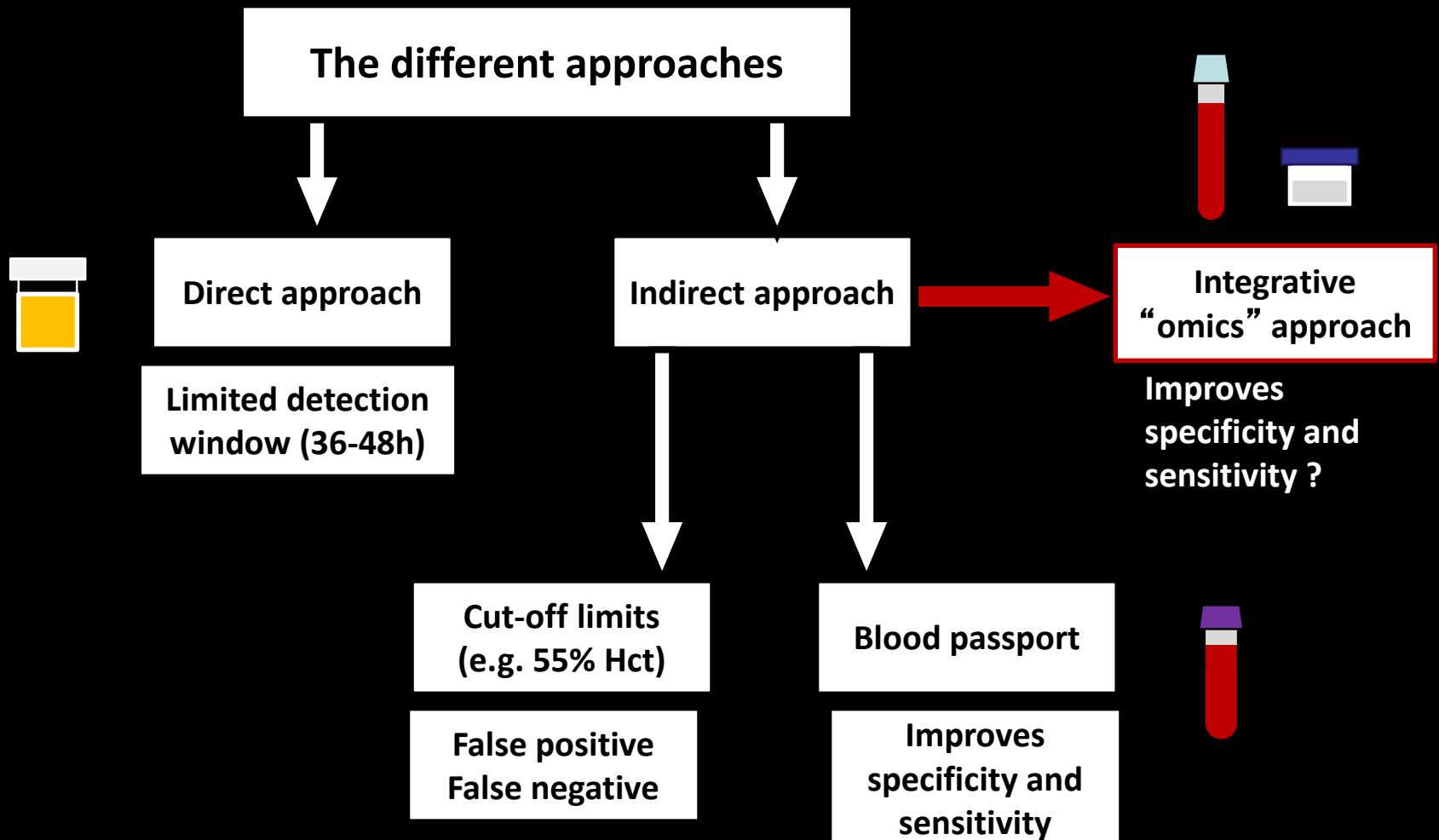
## Current markers of the Athlete Blood Passport do not flag microdose EPO doping

Michael Ashenden • Clare E. Gough •  
Andrew Garnham • Christopher J. Gore •  
Ken Sharpe



(adapted from Sottas et al., 2012)

# Blood Doping Tests



# The “Omics” Cascade

What CAN happen

GENOMICS

BIOINFORMATICS

What APPEARS  
to happen

TRANSCRIPTOMICS

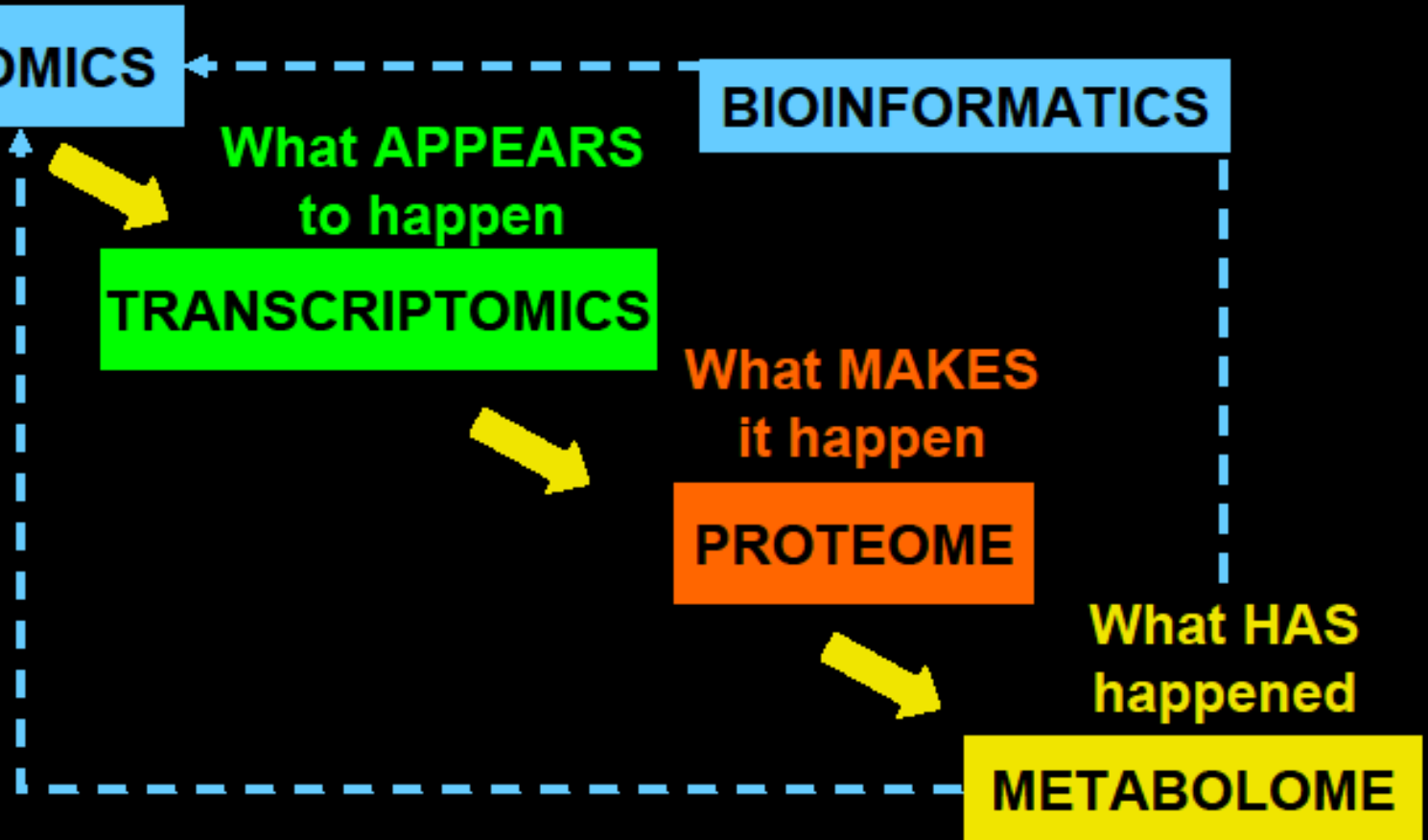
What MAKES  
it happen

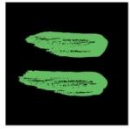
PROTEOME

What HAS  
happened

METABOLOME

PHENOTYPE





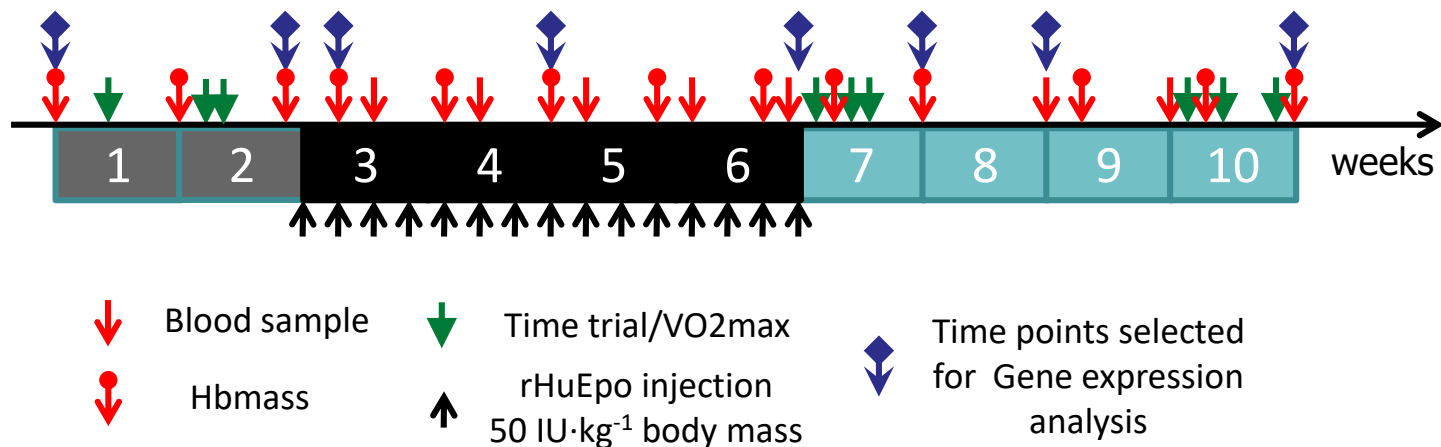
WORLD  
ANTI-DOPING  
AGENCY

play true

# Study design

**SCO Group:** 19 endurance trained males living and training at or near sea-level (Glasgow, Scotland)

**KEN Group:** 20 Kenyan endurance runners living and training at moderate altitude ~2150 m (Eldoret, Kenya)



# Blood analysis

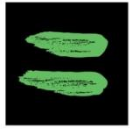


**FIMS Research Laboratory,  
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WORLD  
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play true

# Haematocrit

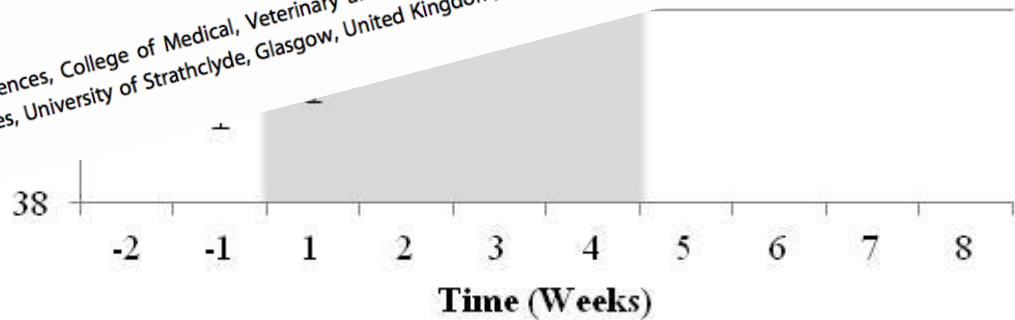


OPEN ACCESS Freely available online

## Haemoglobin Mass and Running Time Trial Performance after Recombinant Human Erythropoietin Administration in Trained Men

Jérôme Durussel<sup>1</sup>, Evangelia Daskalaki<sup>2</sup>, Martin Anderson<sup>1</sup>, Tushar Chatterji<sup>1</sup>, Diresibachew H. Wondimu<sup>1,3</sup>, Neal Padmanabhan<sup>1</sup>, Rajan K. Patel<sup>1</sup>, John D. McClure<sup>1</sup>, Yannis P. Pitsiladis<sup>1\*</sup>

<sup>1</sup> Institute of Cardiovascular and Medical Sciences, College of Medical, Veterinary and Life Sciences, University of Glasgow, Glasgow, United Kingdom, <sup>2</sup> Strathclyde Institute of Pharmacy and Biomedical Sciences, University of Strathclyde, Glasgow, United Kingdom, <sup>3</sup> Department of Medical Physiology, Addis Ababa University, Addis Ababa, Ethiopia



54

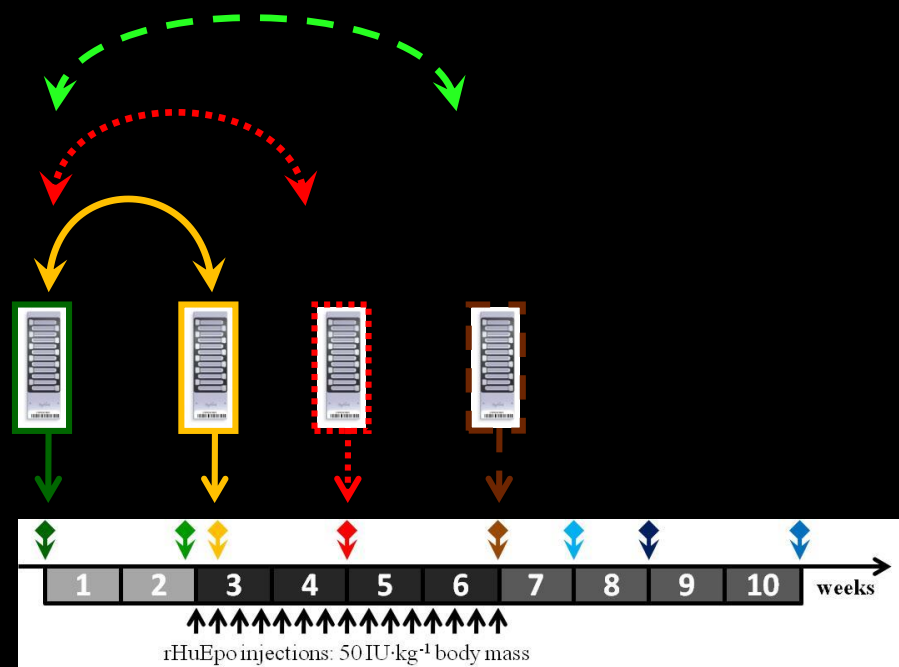
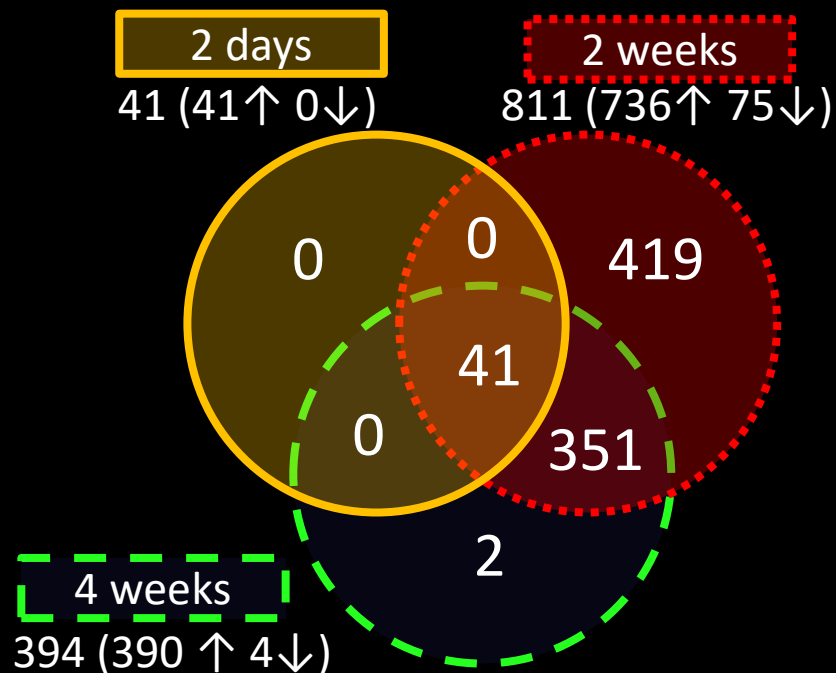
February 2013 | Volume 8 | Issue 2 | e56151

PLOS ONE

# Gene profiling

5 % FDR significant and  $\geq 1.5$ FC: During rHuEpo

SCO (n=18)

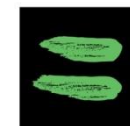
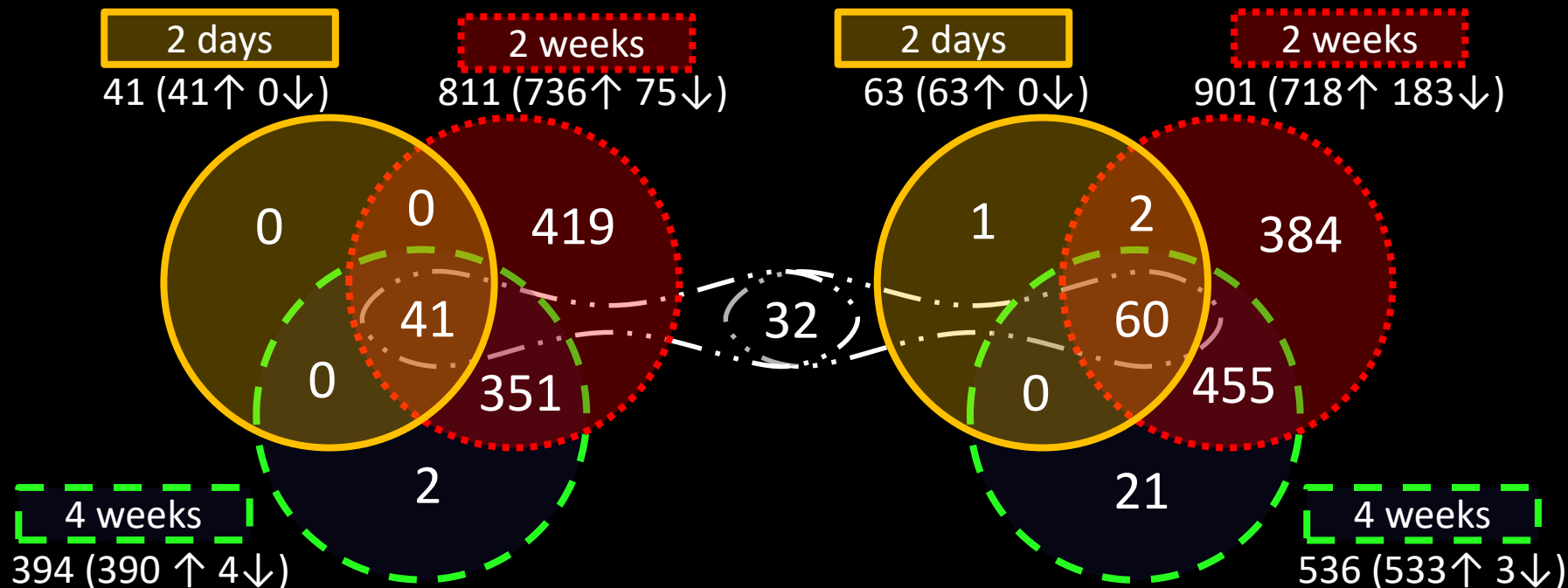


# Gene profiling

5 % FDR significant and  $\geq 1.5$ FC: During rHuEpo

SCO (n=18)

KEN (n=18)



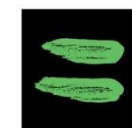
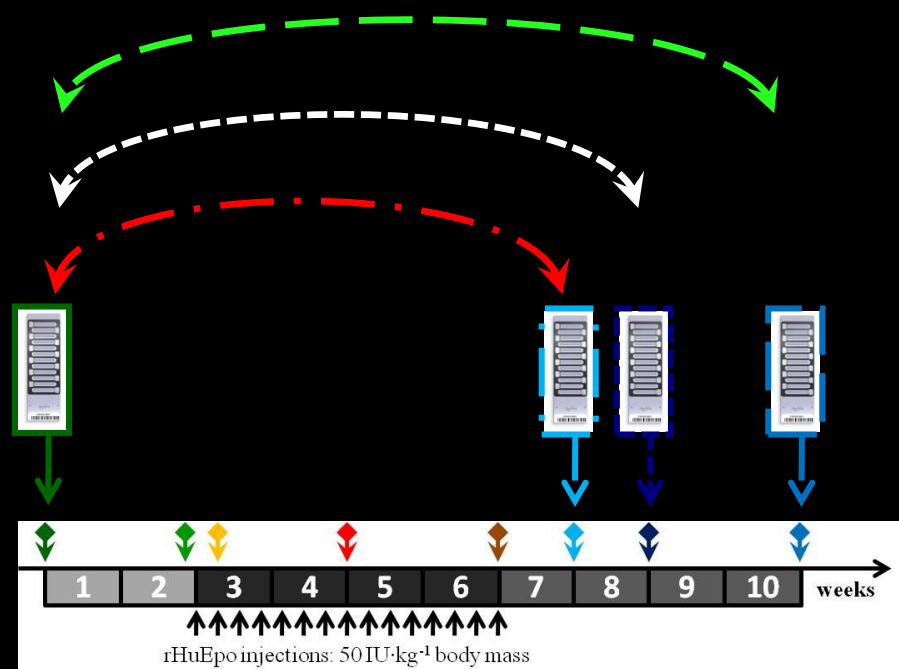
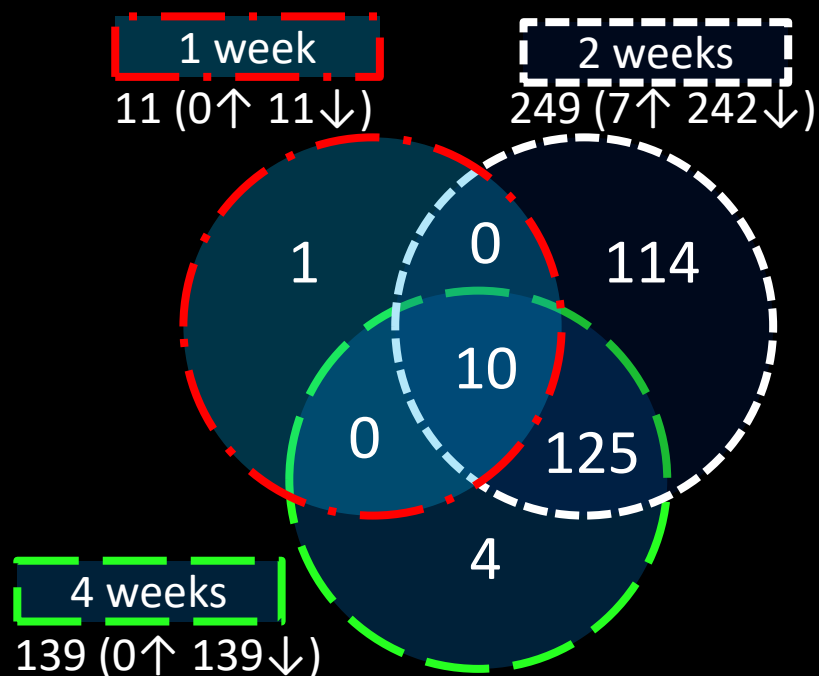
**WORLD  
ANTI-DOPING  
AGENCY**

play true

# Gene profiling

5 % FDR significant and  $\geq 1.5$ FC: Post rHuEpo

SCO (n=18)

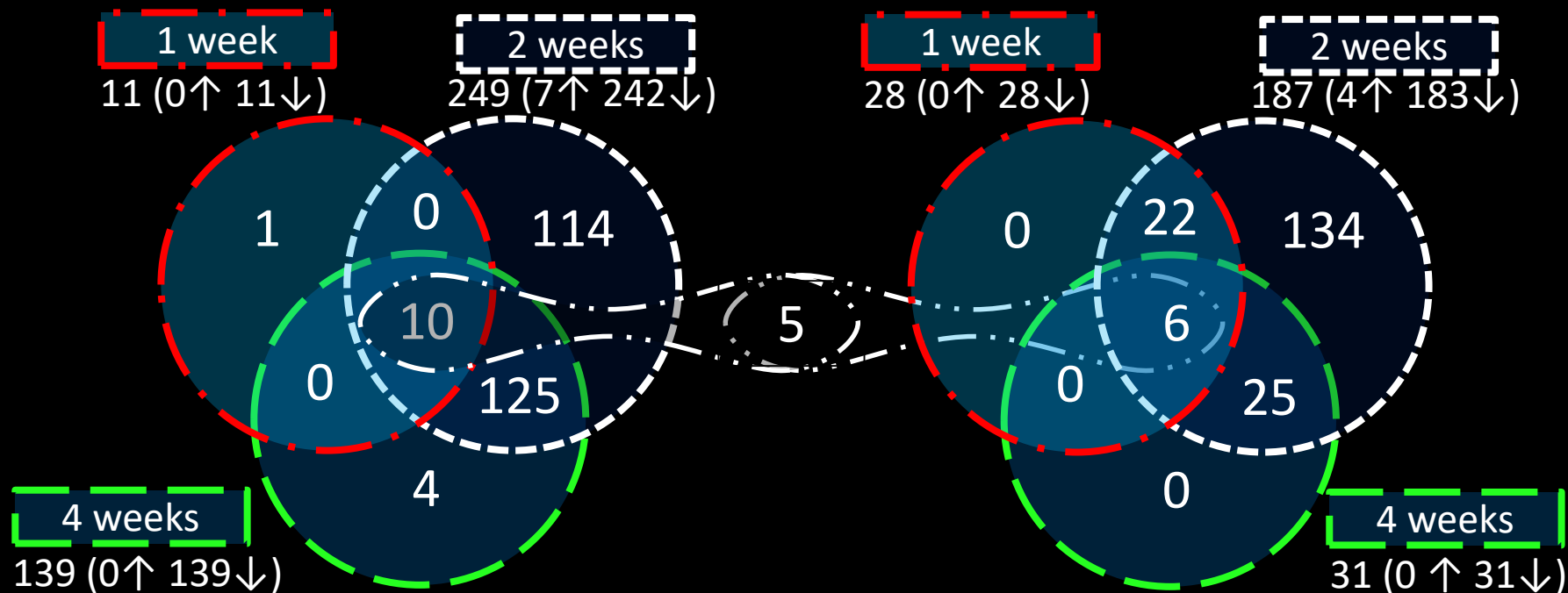


**WORLD  
ANTI-DOPING  
AGENCY**  
play true

# Gene profiling

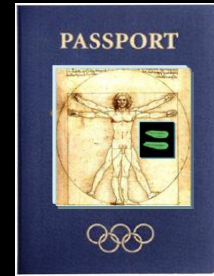
5 % FDR significant and  $\geq 1.5$ FC: Post rHuEpo

SCO (n=18)

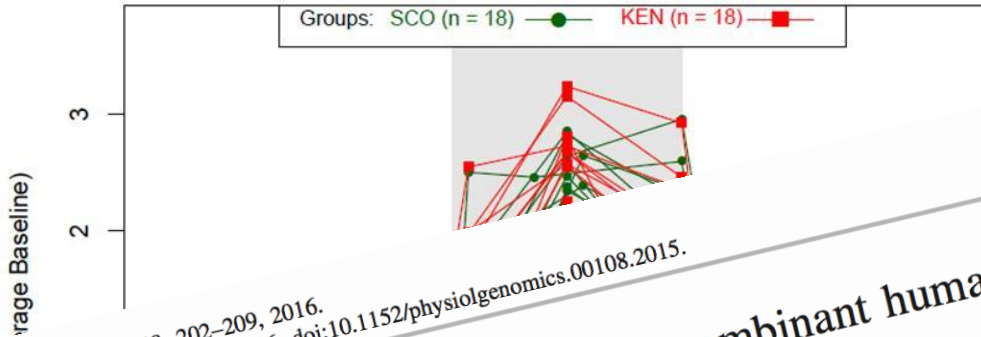


# Future applicability?

## The Athlete Biological Passport?



SCO-KEN: Microarray Results for  
An example of the characteristic gene expression pattern



*Physiol Genomics* 48: 202–209, 2016.  
First published January 12, 2016; doi:10.1152/physiolgenomics.00108.2015.

### Blood transcriptional signature of recombinant human erythropoietin administration and implications for antidoping strategies

Jérôme Durussel,<sup>1</sup> Diresibachew W. Haile,<sup>2</sup> Kerli Mooses,<sup>3</sup> Evangelia Daskalaki,<sup>4</sup> Wendy Beattie,<sup>1</sup> Martin Mooses,<sup>3</sup> Wondyefraw Mekonen,<sup>2</sup> Neford Ongaro,<sup>5</sup> Edwin Anjila,<sup>5</sup> Rajan K. Patel,<sup>1</sup> Neal Padmanabhan,<sup>1</sup> Martin W. McBride,<sup>1</sup> John D. McClure,<sup>1</sup> and Yannis P. Pitsiladis<sup>6</sup>

<sup>1</sup>Institute of Cardiovascular and Medical Sciences, College of Medical, Veterinary and Life Sciences, University of Glasgow, Glasgow, United Kingdom; <sup>2</sup>Department of Medical Physiology, Addis Ababa University, Addis Ababa, Ethiopia; <sup>3</sup>Faculty of Sport and Exercise Sciences, University of Tartu, Tartu, Estonia; <sup>4</sup>Strathclyde Institute of Pharmacy and Biomedical Sciences, University of Strathclyde, Glasgow, United Kingdom; <sup>5</sup>Department of Medical Physiology, School of Medicine, College of Health Sciences, Moi University, Eldoret, Kenya; and <sup>6</sup>FIMS Reference Collaborating Centre of Sports Medicine for Anti-Doping Research, University of Brighton, Eastbourne, United Kingdom

Submitted 28 October 2015; accepted in final form 7 January 2016

Post

# Confounders: Exercise/Altitude/Transfusions



Pierre-Edouard SOTTAS  
Manager, Athlete Biological Passport

Dr Martial SAUGY  
Directeur LAD

# Illumina

Biotechnology company



illumina.com

Illumina, Inc. is an American company incorporated in April 1998 that develops, manufactures and markets integrated systems for the analysis of genetic variation and biological function. [Wikipedia](#)

**CEO:** Francis deSouza (2016–)

**Headquarters:** San Diego, CA

**Founded:** 1998

**Subsidiaries:** Solexa, Avantome Inc, Illumina Singapore Pte. Ltd, [MORE](#) ✓

**Founders:** Larry Bock, Anthony Czarnik, David Walt, Mark Chee, John Stuelpnagel

**Type of business:** Public company

GeneChip HTA 2.0 from  
Affymetrix UK Ltd  
(>285,000 full-length  
transcripts)

>123

## Exercise

45 G  
(EPO 50  
4 we

## Transfusion



GeneChip HTA 2.0 from  
Affymetrix UK Ltd  
(>285,000 full-length  
transcripts)



# NanoString Technologies

Biotech company



nanosttring.com

NanoString Technologies, Inc. is a publicly held biotech company that specializes in development of cancer diagnostics tools. [Wikipedia](#)

**Stock price:** 0F1 (FRA) €13.95 -0.34 (-2.41%)

Jul 14, 8:13 AM GMT+2 - Disclaimer

**Revenue:** 147.6 million USD (2014)

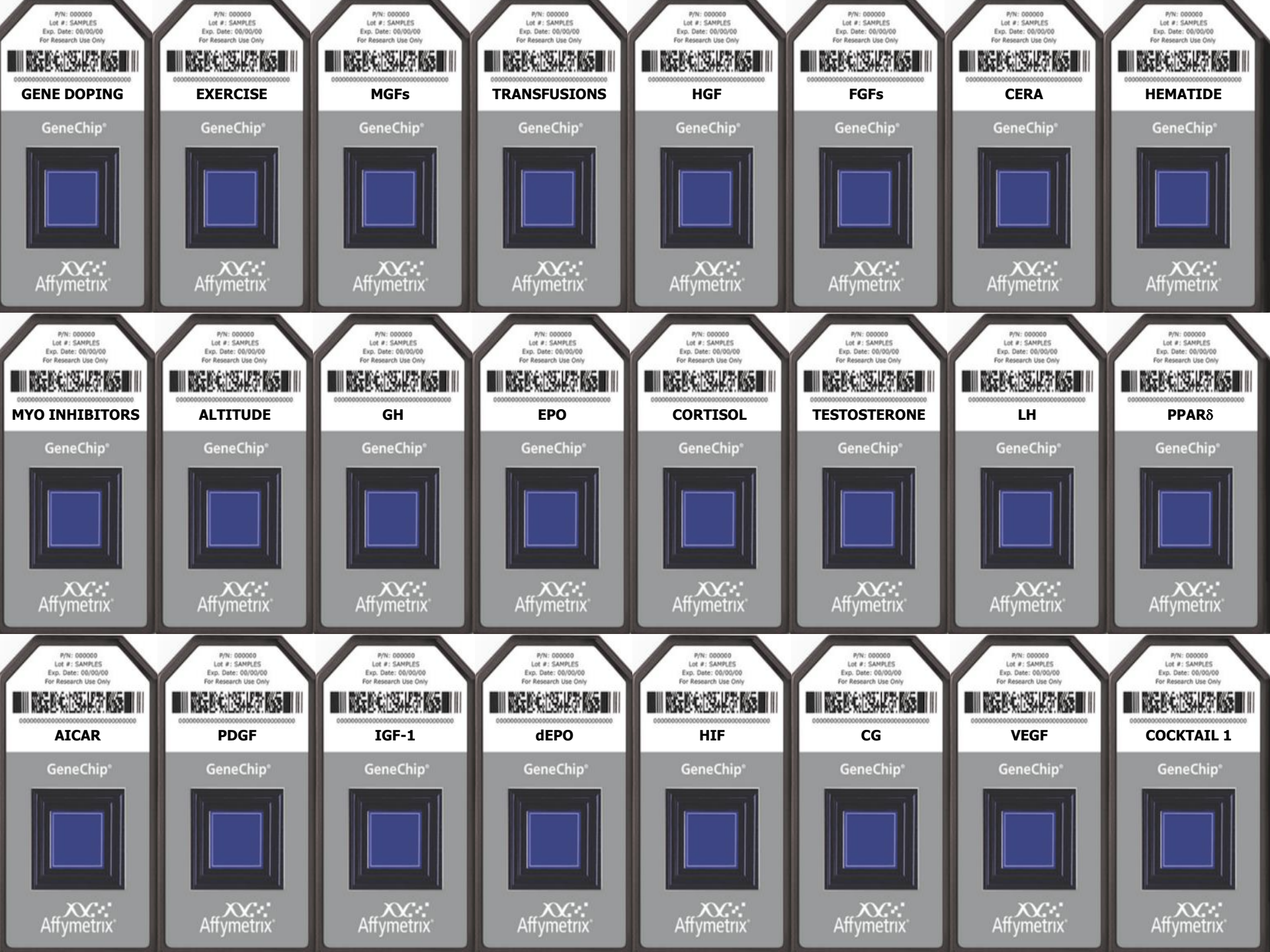
**Headquarters:** Seattle, WA

**Founded:** 2003

**Number of employees:** 270 (2015)

**Total equity:** 204 million USD (2015)

**Founders:** Amber Ratcliffe, Dwayne Dunaway, Krassen Dimitrov



# A Holistic Antidoping Approach for a Fairer Future for Sport

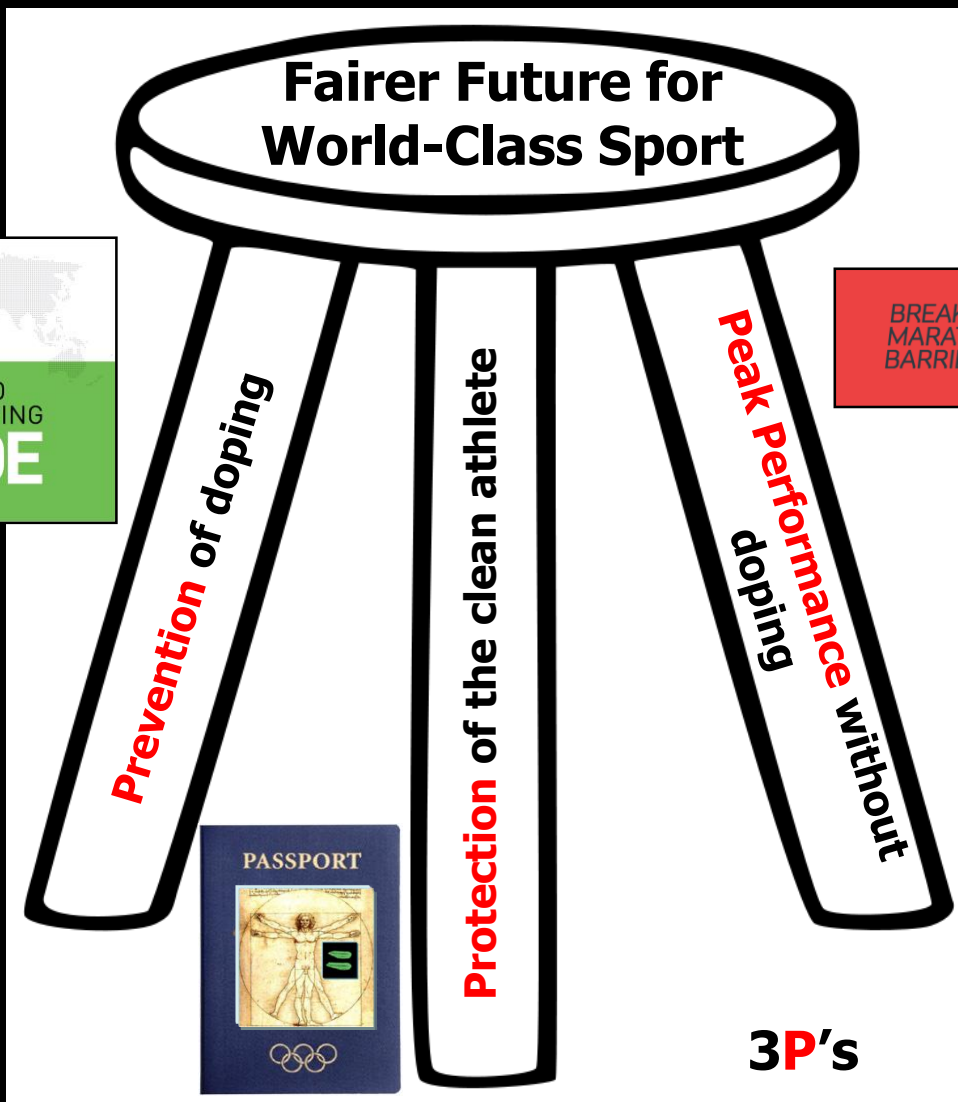
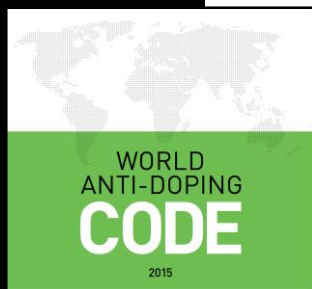
FIMS: INTERNATIONAL PERSPECTIVES

Yannis Pitsiladis, MMedSci, PhD, FACSM<sup>1,2,3</sup>; Ivo Ferriani, BSc<sup>2,4,5</sup>; Michael Geistlinger, PhD, Jur<sup>3,6</sup>; Olivier de Hon, PhD<sup>7</sup>; Andrew Bosch, PhD<sup>8</sup>; and Fabio Pigozzi, MD, PhD<sup>2,3,9</sup>

CURRENT  
**SPORTS MEDICINE**  
REPORTS



July/August 2017 - Volume 16 - Issue 4



[www.sub2hrs.com](http://www.sub2hrs.com)

'What excites me is understanding the limits  
of human performance – what can man do?'

YANNIS PITSLADIS, a physiologist and the founder of the Sub2 Project, shown running at the Dead Sea.

# MAN vs. MARATHON

One scientist's quixotic quest to propel a runner past the two-hour barrier. PAGE 5

Article by JÉRÉ LONGMAN < Photographs by URIEL SINAI



# Billion dollar race to break 2-hour marathon mark is afoot

By DANICA KIRKA | Published May 17, 2017 | [Markets](#) | [Associated Press](#)



www.sub2hrs.com

# COUNTDOWN TO THE FIRST SUB2HR MARATHON

## NO LONGER A MATTER OF IF BUT RATHER WHEN

The first dedicated international research initiative made up of specialist multidisciplinary scientists from academia, elite athletes and strategic industry partners.



@SUB2HRS



A FANTASTIC LAUNCH OF THE "ORIGINAL" SUB2 PROJECT IN AFRICA; HIGHLIGHTS ARE AVAILABLE AT:  
[HTTPS://T.CO/XLWHWOQHOJ...](https://t.co/XLWHWOQHOJ...) [HTTPS://T.CO/W9APDNRFNV](https://t.co/W9APDNRFNV) 1 DAY AGO



**Sub2hrsmarathon** @Sub2hrs · 7h



A fantastic launch of the "Original" Sub2 Project in Africa; highlights are available at:

[facebook.com/sportssciencea](https://facebook.com/sportssciencea)  
[@Sportscience\\_sa](https://twitter.com/Sportscience_sa)



# OUR OBJECTIVES

While some consider we are generations away from witnessing a sub two hour marathon, the sub2hr project team believe this feat can be achieved within five years by applying a dedicated scientific approach.

## PHASE 1 // DEVELOPMENT

**Will involve setting up the global consortium, advertising the ambitious objectives and securing the necessary sponsorship to initiate the project.**

For an ambitious project of this kind to succeed it will require a dedicated group of multidisciplinary scientists from academia and industry with specialist expertise ranging from laboratory to field research. These world-leading scientists will require substantial funding to motivate and support their continued involvement in the SUB2 project. The make-up of the project consortium will be guided by this requirement and the need to develop state-of-the-art technologies and approaches. The major and unlimited prospects for commercial benefit will ensure the development of numerous small, medium and large enterprise partnerships with industry; cornerstone for the success of the SUB2 project. An estimate of \$30million of funding will be sought over the next 5 years.



# OUR OBJECTIVES

While some consider we are generations away from witnessing a sub two hour marathon, the sub2hr project team believe this feat can be achieved within five years by applying a dedicated scientific approach.

## PHASE 2 // IMPLEMENTATION



**Aimed at establishing the project and achieving the 1:59:59 objective.**

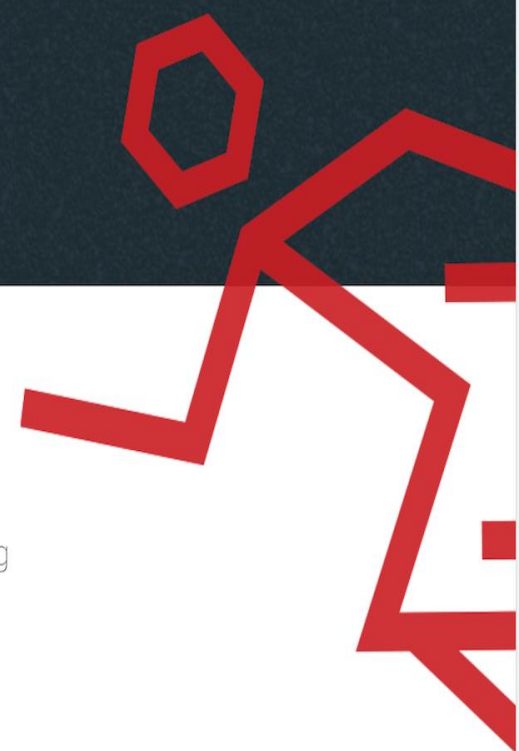
The level of success achieved during Phase 1 will dictate to a large extent whether all necessary requirements will have been attained for the successful implementation of the SUB2 project. While Phase 1 and 2 have separate aims, objectives and timeframes, these distinct phases will commence from the onset of the project. Cornerstone to the successful implementation of the project will be securing the engagement and full support of all necessary stakeholders including scientists and medical personnel, industry, sponsors, athletes, athlete management agencies and local, national and international sporting governing bodies.

# THE SCIENCE

The SUB2 project team believe a sub 2hr marathon can be achieved within five years by applying a dedicated scientific approach involving the very latest knowledge in key areas such as genetics (and the “[omics]”), bioenergetics, biomechanics, nutrition, sports engineering and coaching and performance science.

## THE DELIVERABLES

These priority areas will be arranged in ten work packages each comprising specific milestones and deliverables and led by a senior scientist or medical/biomedical professional. Leaders of each work package will also constitute the SUB2 Project Steering Committee.





## DATA MANAGEMENT AND BIOINFORMATICS

The collection, cleaning and storage of data. *Run by Guan Wang*

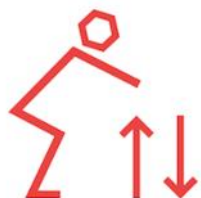
[// LEARN MORE](#)



## NUTRITION

Dealing with the development of individualised nutritional strategies optimised for the different periods of training and competition. *Run by Andrew Bosch*

[// LEARN MORE](#)



## BIOENERGETICS

Exploring the relationship between maximal aerobic capacity and running economy and the influence of body size, anthropometry and running form on thermoregulation, running economy and fuel use.

[// LEARN MORE](#)



## BIOMECHANICS AND MODELLING

Biomechanics and modeling will focus on lab and field approaches to monitoring gait mechanics and ground reaction forces in order to maximize racing speeds. *Run by Peter Weyand*

[// LEARN MORE](#)

# Sub2-Maurten Partnership



25 September, 2016







## DRINK MIX 160

€39.20 INCL. 12% VAT.

If hydration is your main priority but you still want a lot of energy – this is the product for you. One serving contains 40 grams of carbohydrates. Each box contains 18 servings.



Mo Farah

11 August at 08:31 · 🌐

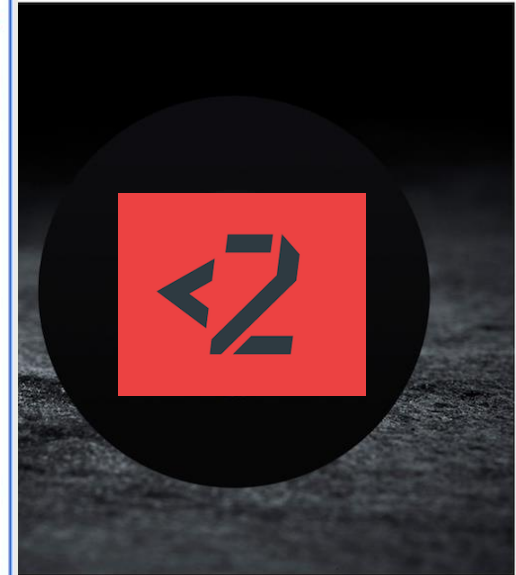
Yeszzz! I am now an official ambassador for Swedish tech start-up @Maurten. Their sports drinks are the best out there. They are completely natural, very easy to drink and contain much higher concentrations of energy than the traditional sports drinks. I'm looking forward to working with them as I make the transition into marathon running this autumn - [www.maurten.com](http://www.maurten.com)



4.3k Likes 131 Comments 76 Shares

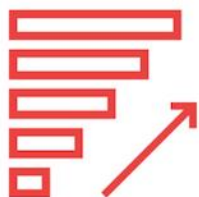
ULTS

QUESTIONS?



## BE ANNOUNCED

innovative product using Maurten technology will arrive here during 2017!



## TRAINING

Dealing with the development of intelligent training methods utilising genetic technologies and linking these technologies to the very latest training aids.

[// LEARN MORE](#)



## SPORTS MEDICINE AND PHYSIOTHERAPY

All the sports medicine and physiotherapy requirements of the SUB2 project. *Run by Nick Webborn*



## RACE PREPARATION AND PERFORMANCE

Will deal with developing and executing individualised and the SUB2hr team athletes race preparation and strategy



## ANTI-DOPING

Promoting clean marathon running i.e. high performance marathon running without doping by applying thorough anti-doping education and regular doping controls (blood and urine). The world record can be broken by using science, medicine and technology, and not having to resort to doping to do so. *Run by Olivier de Hon*

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## PRODUCT DEVELOPMENT

Focusing on new product development and spin offs linked with the project objectives.



## TECHNOLOGIES AND APPLICATIONS

Analyzing, with the use of satellite and ground data, the environmental (mainly thermal) conditions of past marathon routes but most importantly by providing, real time information during the race on ambient thermal conditions *Run by Constantinos Cartalis and Iphigenia Keramitsoglou*

[// LEARN MORE](#)



## PSYCHOBIOLOGY

Investigating the relationship between physiological responses when running below, at and above 2hr marathon pace and related psychological scales. *Run by*

[// LEARN MORE](#)



## RUNNING ACADEMY

Working towards the future development of distance running by actively seeking promising young runners and nurturing their running development from an early age with a view to even greater performances in the years ahead. *Run by*

[// LEARN MORE](#)

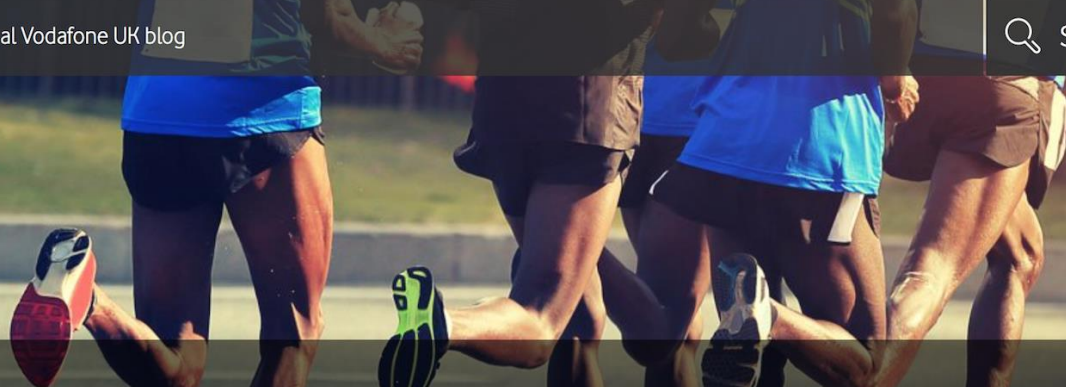


# 01:59:59: How SUB2 is using Vodafone tech to transform long distance running

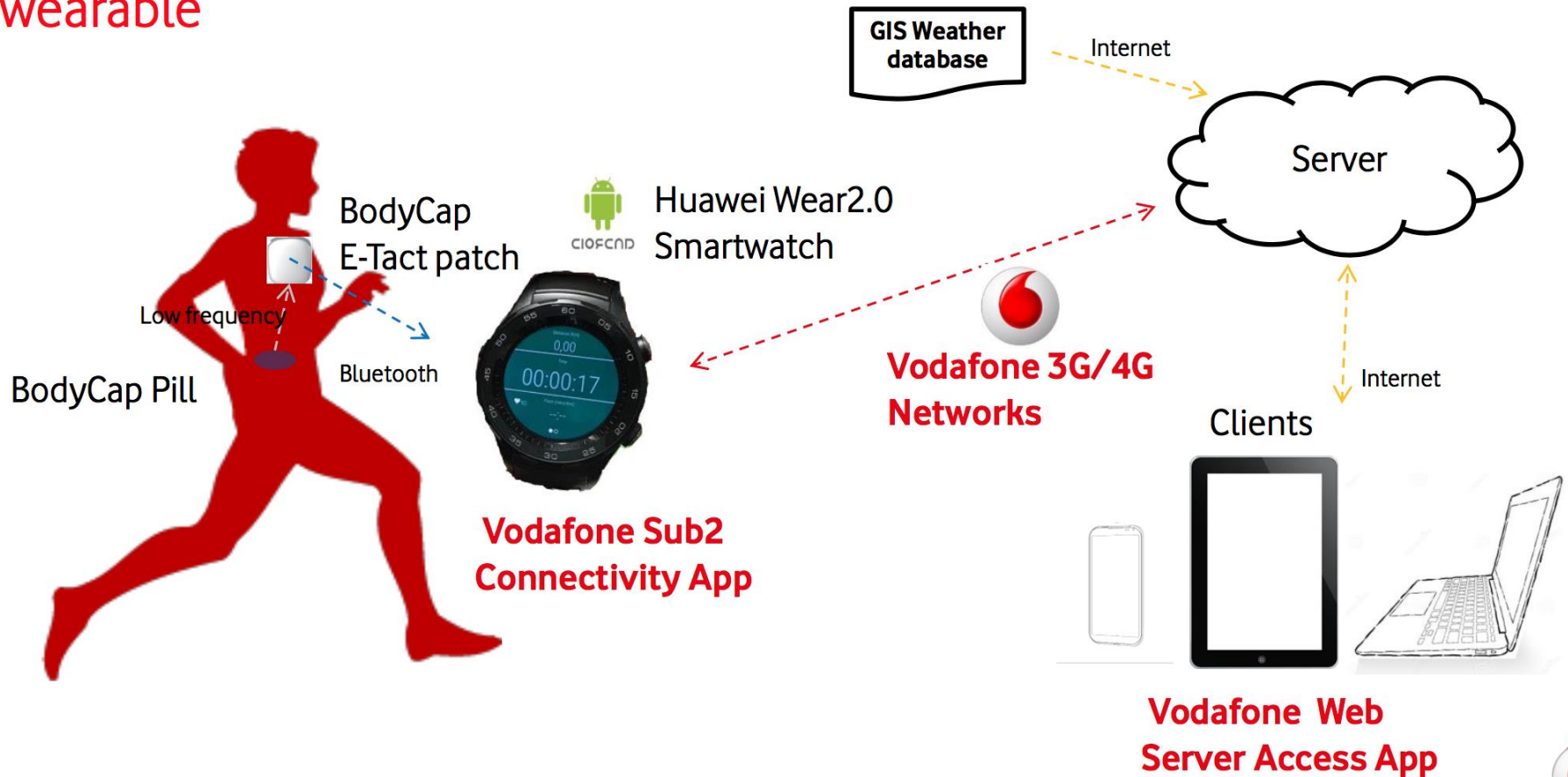
By Adam Bunker - 25 April 2017

Feeling inspired by last weekend's London Marathon? Find out how we're helping the world's fastest runners break new boundaries with Vodafone technology...





Two applications have been developed to provide connectivity to the wearable



# Sub2-Vodafone Partnership



# Sub2-Vodafone Partnership



**Kyriakos Exadaktylos**

Group Head of Network Standards  
Networks - Strategy & Architecture  
Vodafone Group Technology



# Sub2-Vodafone Partnership



# New Sub2 Partnership





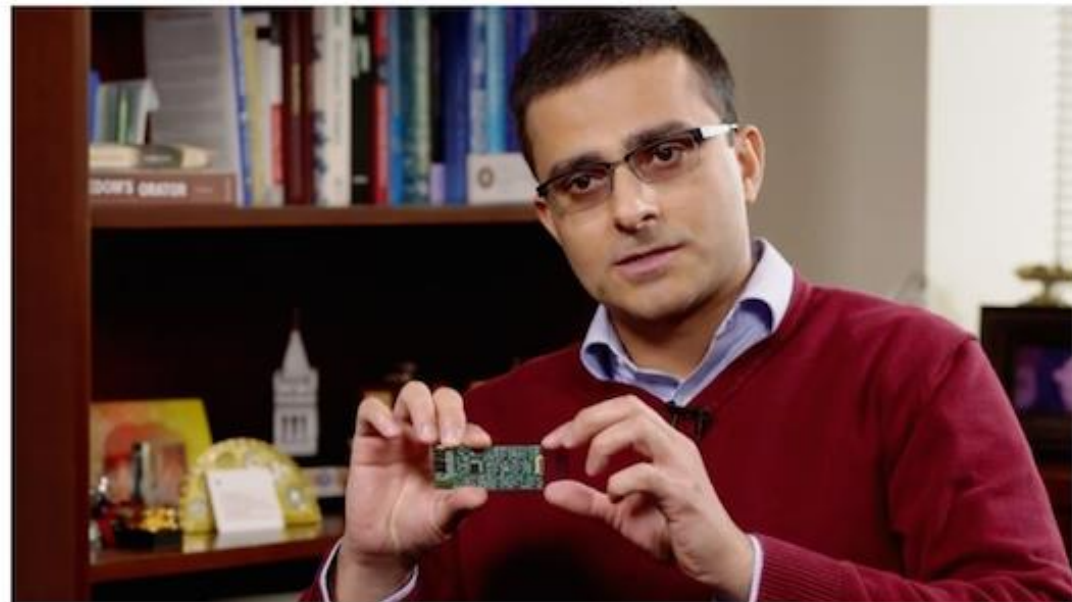
## Wearable sweat sensor paves way for real-time analysis of body chemistry

Flexible plastic sensor sends molecular test results to a smartphone.

Linda Geddes

27 January 2016

[Rights & Permissions](#)



Roxanne Makasdjian and Stephen McNally

Ali Javey, of the University of California, Berkeley, shows the flexible, wearable sweat-sensing device his team has created.

### Gaming the gamers



#### Can a video game company tame toxic behaviour?

Scientists are helping to stop antisocial behaviour in the world's most popular online game. The next stop could be a kinder Internet.



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*Nature* | 31 March 2016

## 44th BMW BERLIN-MARATHON on 24 September 2017

**ABBOTT**  
WORLD MARATHON MAJORS



**matrix**

of Thermo Fisher Scientific