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Crowd Science and Citizen Science

Josep Perelló

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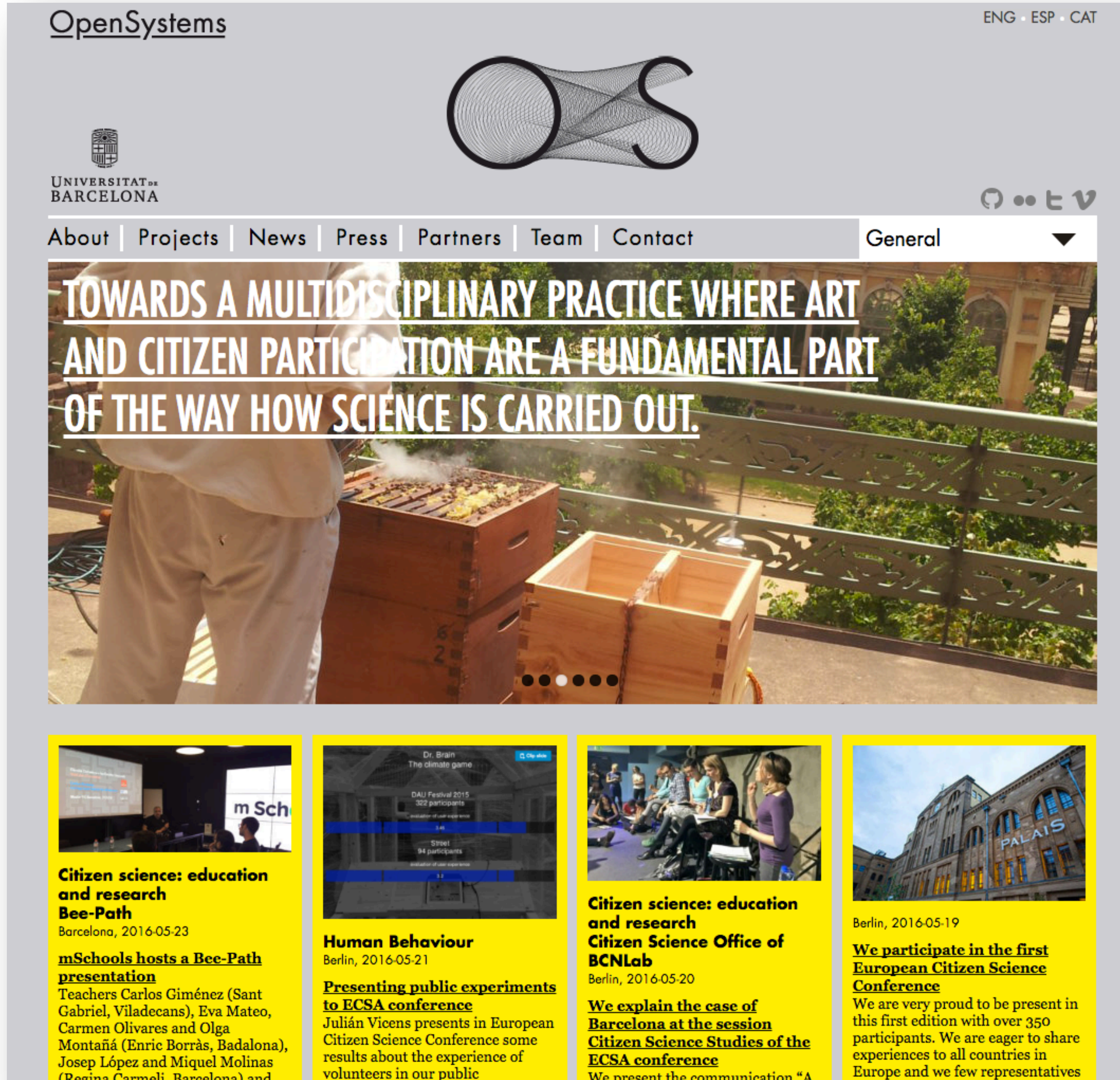


Josep Perelló
josep.perello@ub.edu
@JosPerello
Institute of Complex Systems UBICS

OpenSystems
Departament de Fisica
de la Matèria Condensada
Universitat de Barcelona

@OpenSystemsUB
Desde 2012

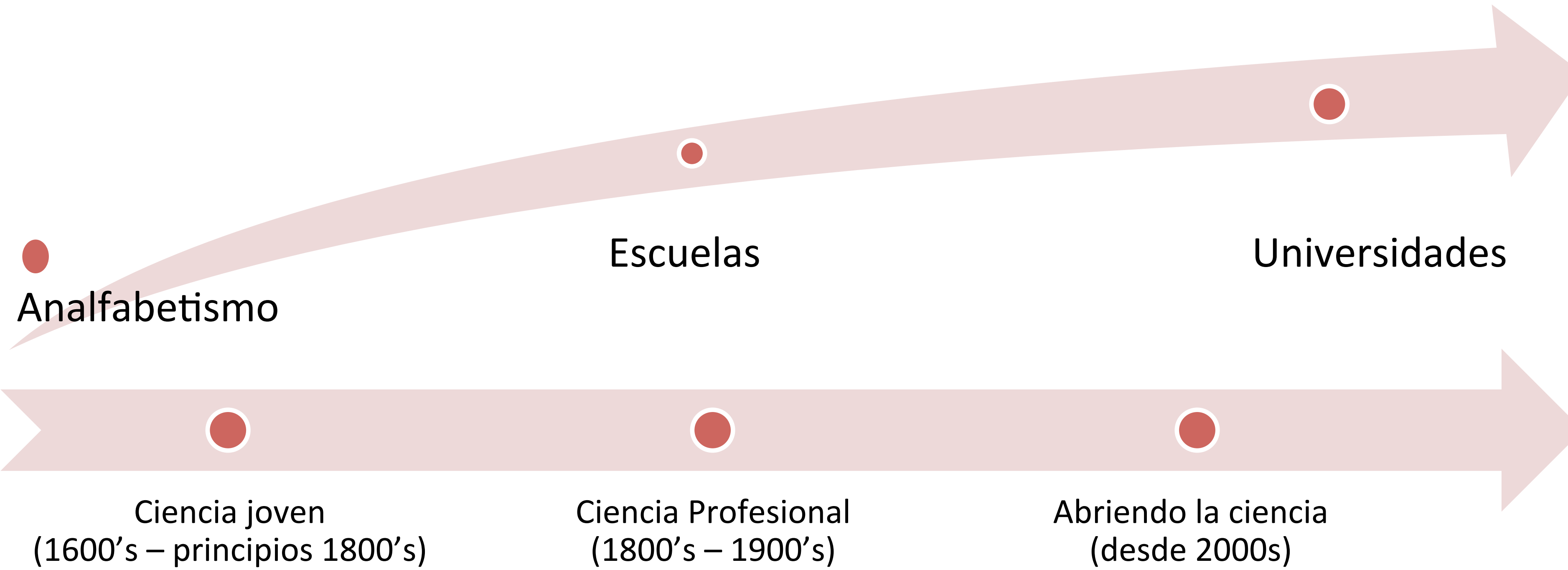
Ciencia Ciudadana

"participación del público en general en actividades de investigación científica, donde los ciudadanos contribuyen activamente, ya sea con su esfuerzo intelectual, su conocimiento de campo, o con sus herramientas y recursos"

Green Book of Citizen Science
Socientize (IberCivis, proyecto EU)

Proyecto OpenBeeResearch. Abejas Urbanas, en HANGAR

Ciencia ciudadana y ciencia



Ciencia ciudadana y ciencia

Ciencia ciudadana como ciencia de los señores o señoras

Anafalbetismo

Escuelas

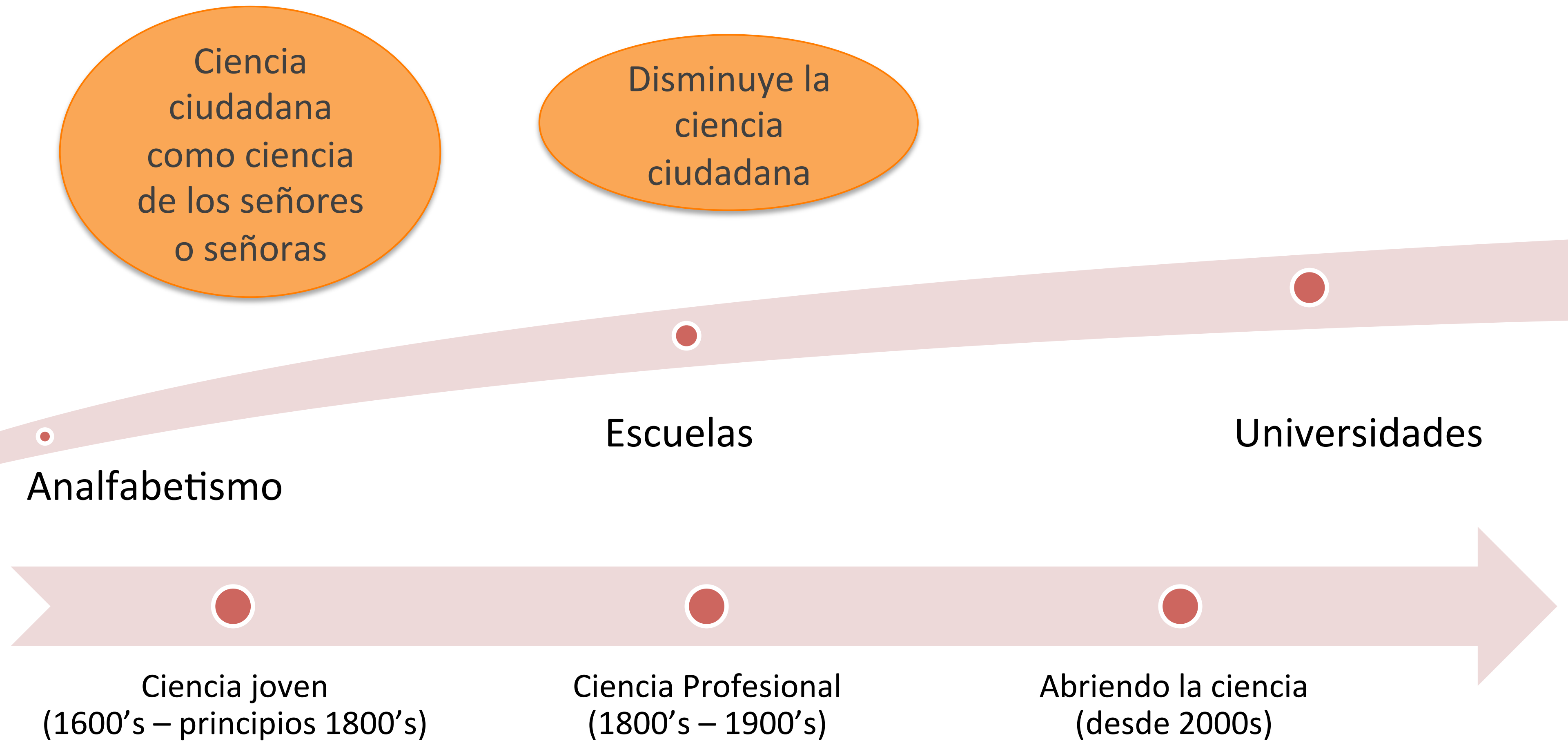
Ciencia joven
(1600's – principios 1800's)

Ciencia Profesional
(1800's – 1900's)

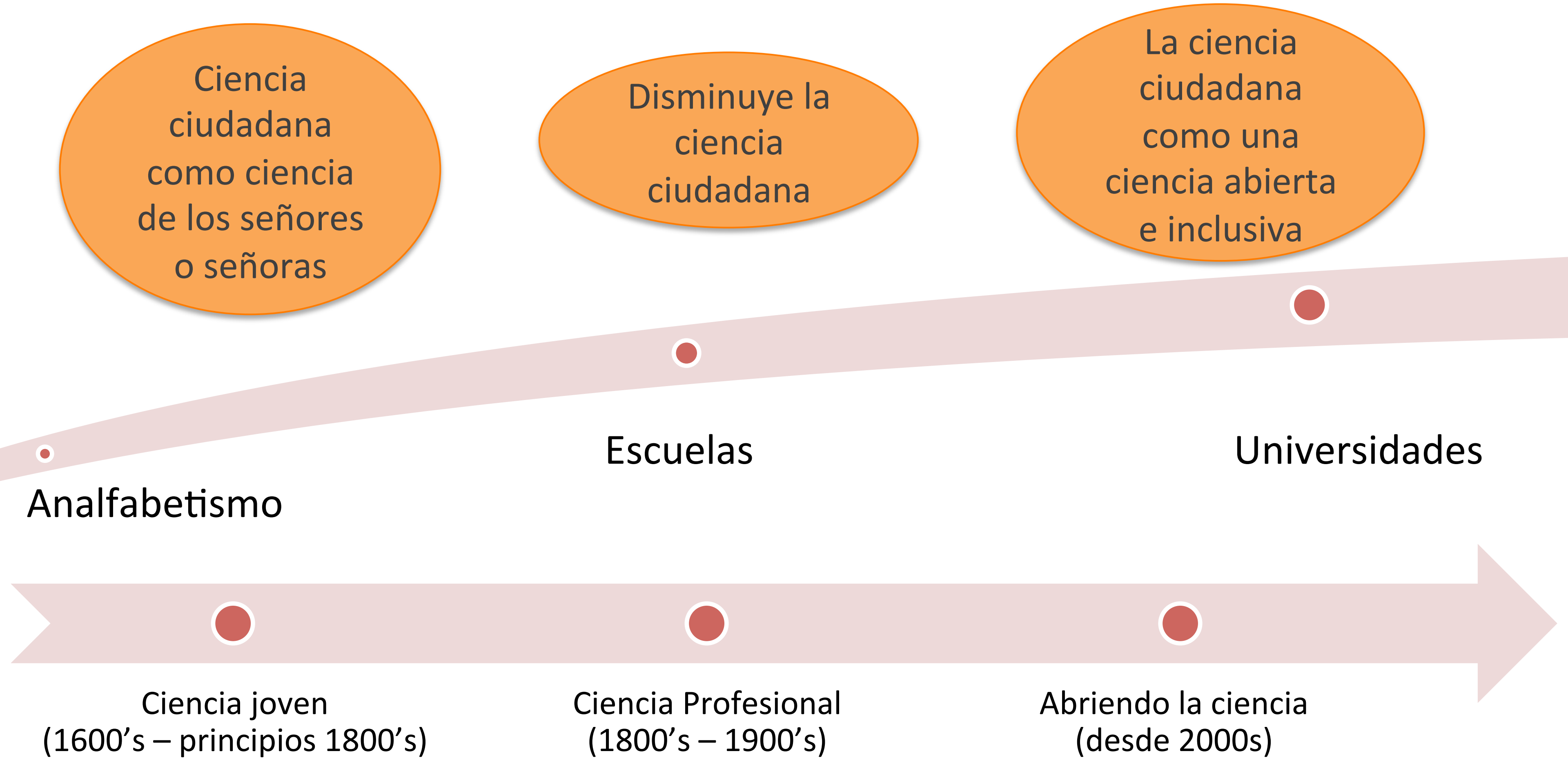
Ab

Mary Anning (1799-1847)

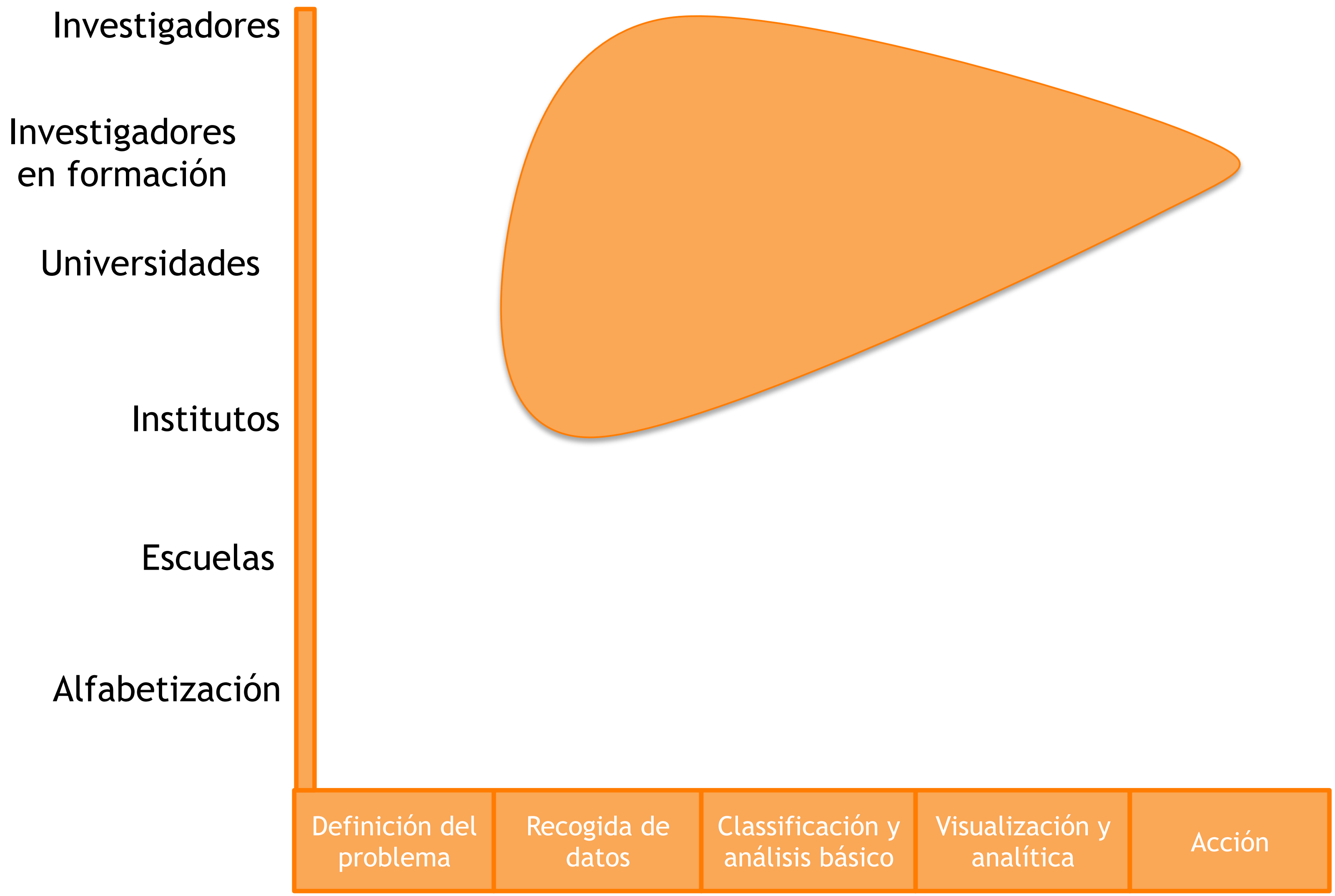
Ciencia ciudadana y ciencia



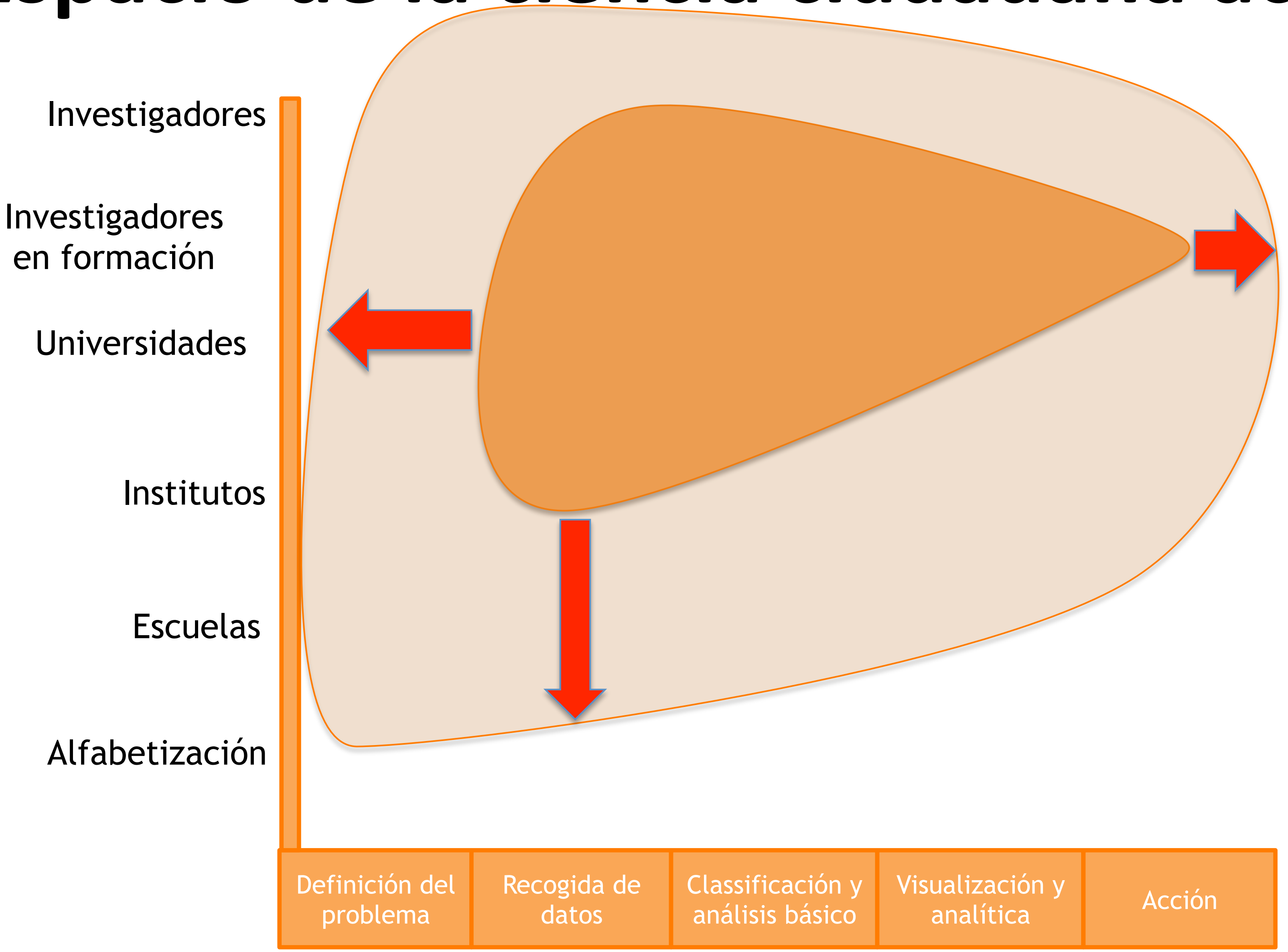
Ciencia ciudadana y ciencia



Espacio de la ciencia ciudadana actual



Espacio de la ciencia ciudadana actual



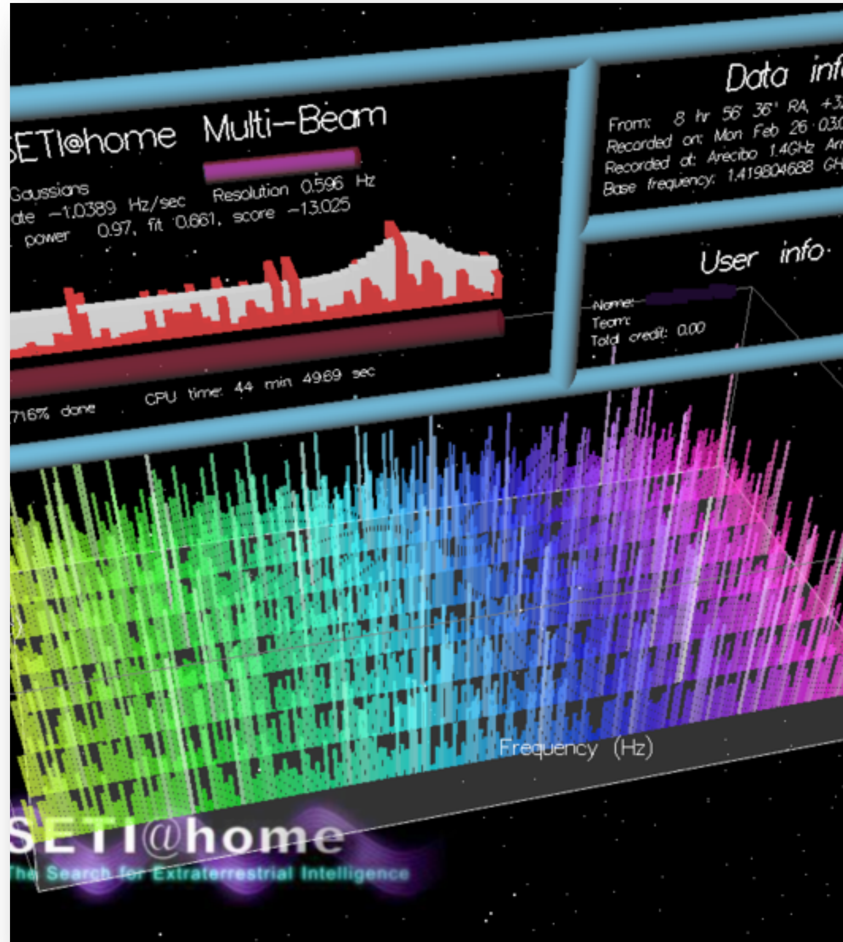
Clasificación de proyectos de ciencia ciudadana

Niveles de participación	Tareas
Nivel 4. Ciencia Ciudadana Extrema	Investigación colaborativa. Definición de problema, análisis y recogida de datos
Nivel 3. Ciencia participativa	Participación en la definición del problema y en la recogida de datos
Nivel 2. Inteligencia distribuida	Ciudadanos como intérpretes básicos
Nivel 1. Crowdsourcing	Ciudadanos como sensores

Otros inicios de la ciencia ciudadana

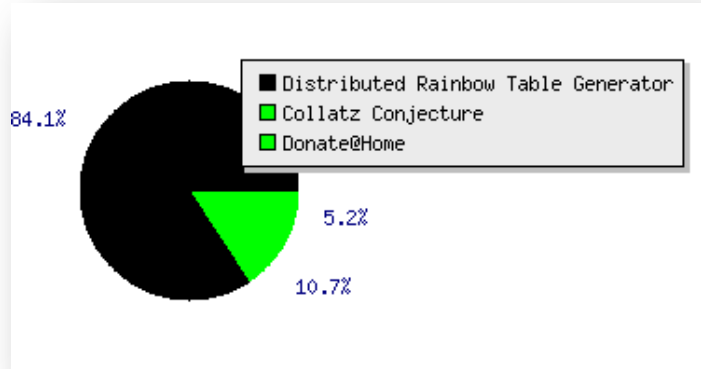
Proyecto SETI@home.

1. Año 1999. Uso de computadoras domésticas parar la búsqueda de vida alienígena, barrido de señales de radio-telescopios
2. 2002. Plataforma de software única para multitud de proyectos: Berkeley Open Infraestructure for Network (BOINC)
3. Desde 2005: dozenas de projectes i centenares de millares de usuarios en todo el mundo



http://boinc.berkeley.edu

Berkeley Open Infraestructure for Network (BOINC)



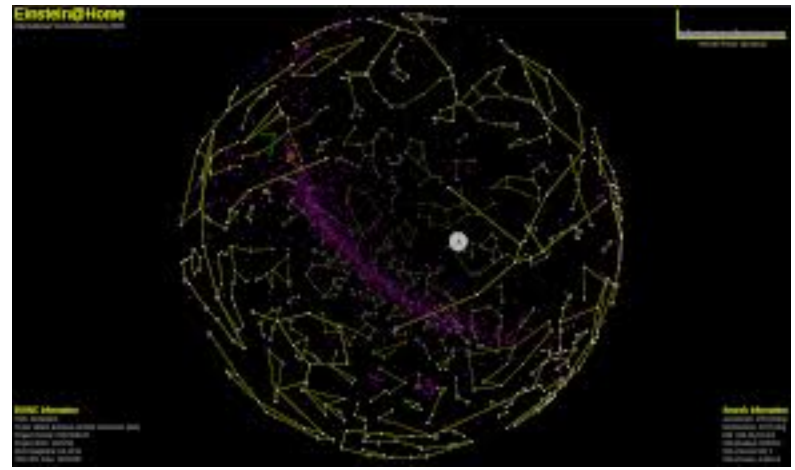
Estadísticas BOINC a 14 de abril 2013. Usuarios 2.454.400. Servidores 8.993.246. Paises 285 - IBERCIVIS (Saragossa)

Y más astronomia…

Proyecto Einstein@home. Capta datos del Laser Interferometer Gravitational Wave Observatory

1. Marzo 2009. Un ordenador de Helen Colvin (Iowa) detecta señal de púlsar no detectado anteriormente.
2. 3 días después el servidor del Departament of Music Informatics de la Universidad de Mainz confirma y vuelve a detectar la señal.

Publicación en Science -12 Agosto 2010.

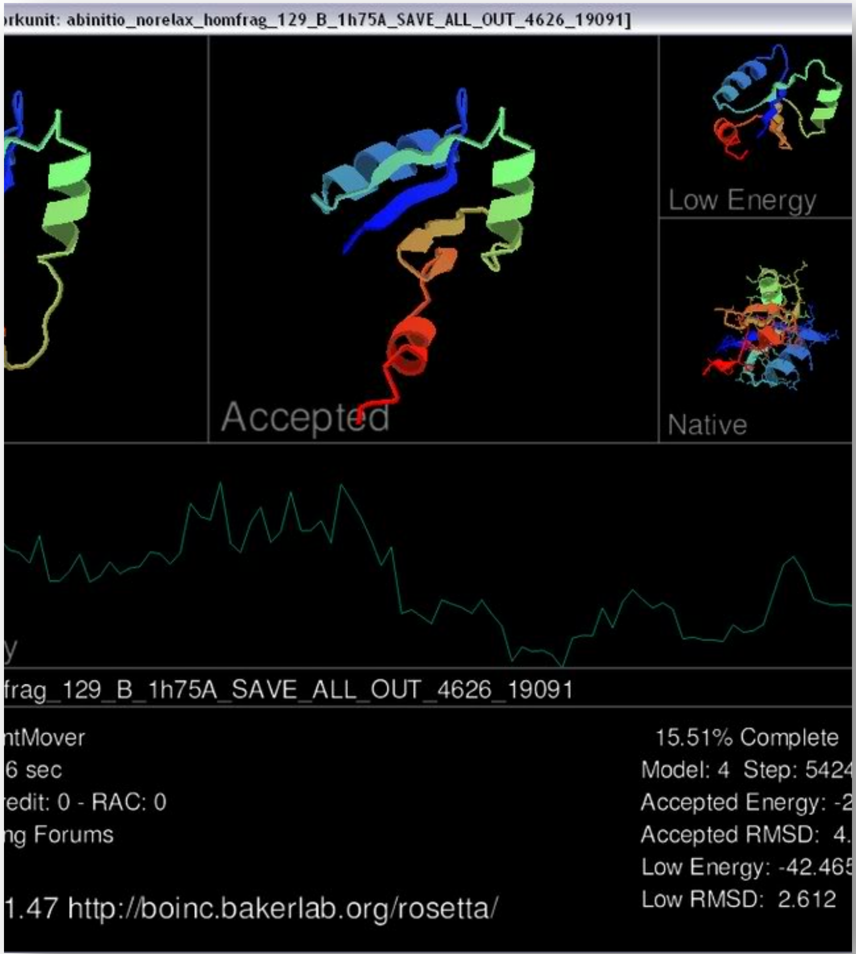


La computación distribuida

Rosetta@home (2005)

1. Usuarios se bajan un código para encontrar la forma "más natural".
2. El esfuerzo computacional salía en en salvapantallas

Voluntario: "Puedo ver cómo otra forma puede ajustarse mejor"



De la computación distribuida al juego

Foldit (2008), un juego online

1. Los jugadores compiten, colaboran, desarrollan estrategias, acumulan puntos y suben de nivel
2. 240.000 jugadores, 2.200 activos por semana.
3. 22 enero 2012: Creación de una enzima. Reto planteado por investigadores. Nature Biotechnology

Los jugadores han dado “un giro refrescante a la ingenieria de las enzimas”

“Puedes explorar cosas que parecen una locura”.

El caso de Galaxy Zoo

http://www.galaxyzoo.org

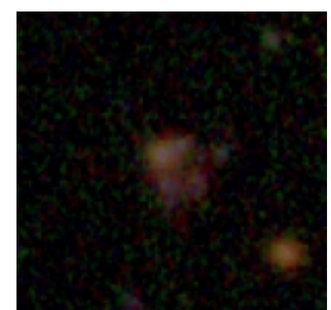
Clasifica Galaxias (espiral o elípticas). Proyecto de la Universidad de Oxford con un banco de imágnes del telescopio Huble. Inicio: 2007

“Para entender cómo las galaxias se han formado, necessitamos tu ayuda.”

“Si eres rápido, puedes ser laprimera persona de ver las galaxias que se te piden clasificar

+1,25 milions de galàxies classificades (hasta 2010)

Decenas de publicaciones



Una nueva manera de hacer ciencia?

No es aún mainstream

David Anderson, fundador de BOINC: “Hay la idea que, con estas prácticas, [los científicos] han cedido el control y que su importancia disminuiria”.

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Accelerating Citizen Science and Crowdsourcing to Address Societal and Scientific Challenges

SEPTEMBER 30, 2015 AT 6:00 AM ET BY TOM KALIL AND DAVE WILKINSON

Summary: Today, the White House is hosting a forum on citizen science and crowdsourcing.

While only a fraction of Americans are formally trained as professional scientists and engineers, everyone can contribute to science, engineering, and technology through open science and innovation approaches, such as citizen science and crowdsourcing projects.

Citizen science encourages members of the public to voluntarily participate in the scientific process. Whether by asking questions, making observations, conducting experiments, collecting data, or developing low-cost technologies and open-source code, members of the public can help advance scientific knowledge and benefit society.

Through **crowdsourcing** – an open call for voluntary assistance from a large group of individuals – Americans can study and tackle complex challenges by conducting research at large geographic scales and over long periods of time in ways that professional scientists working alone cannot easily duplicate. These challenges include understanding the structure of proteins related viruses in order to support development of new medications, or preparing for, responding to, and

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ERC Newsletter September 2015 - It's time for citizen science!

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▸▸▸ research in the spotlight

It's time for citizen science!

FOLDIT IMAGE: UNIV. WASHINGTON CENTER FOR GAMESCIENCE; ARTWORK BY W. FERNANDES

People power

Networks of human minds are taking citizen science to a new level, reports **Eric Hand**.

The whole thing began by accident, says David Baker, a biochemist at the University of Washington in Seattle. It was 2005, and he and his colleagues had just unveiled Rosetta@home — one of those distributed-computing projects in which volunteers download a small piece of software and let their home computers do some extracurricular work when the machines would otherwise be idle. The downloaded program was devoted to the notoriously difficult problem of protein folding: determining how a linear chain of amino acids curls up into a three-dimensional shape that minimizes the internal stresses and strains — presumably the protein's natural shape. If the users wanted, they could watch on a screen saver as their computer methodically tugged and twisted the protein in search of a more favourable configuration.

Thousands of people were signing up for Rosetta@home, says Baker, which was gratifying, but not entirely surprising; this kind of digital citizen science had become almost routine by then. It was first popularized in 1999 by the SETI@home project at the University of California, Berkeley (UCB), which harnessed volunteers' computers to sift through radio telescope data in search of alien signals. And in 2002, UCB engineers had released a generalized version of the software known as the Berkeley Open Infrastructure for Network Computing (BOINC). By 2005, there were dozens of active BOINC projects — Rosetta@home among them — and hundreds of thousands of users worldwide.

But what was surprising, says Baker, was that the Rosetta@home volunteers quickly began to chafe at the painfully slow progress of their screen saver. "People started writing in saying, 'I can see where it would fit better this way,'" he says.

In retrospect, this should have been obvious: even a small protein can have several hundred amino acids, so computers have to plod through thousands of degrees of freedom to arrive at an optimum energy state. But humans, blessed with a highly evolved talent for spatial manipulation, can often see the solution intuitively.

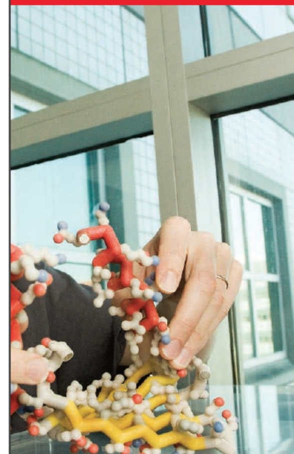
> "We're at the dawn of a new era, in which computation between humans and machines is being mixed."

Recognizing an unexpected opportunity, Baker enlisted the help of computer-scientist colleagues. By mid-2008, they had created an interface for Rosetta@home that not only allows users to assist in the computation, but gives them an incentive to do so by turning it into an online game. In the game Foldit, players compete, collaborate, develop strategies, accumulate game points and move to different playing levels — all while folding proteins.

And it works. This week, Baker and his colleagues publish evidence that top-ranked Foldit players can fold proteins better than a computer (see page 756). By collaborating, these top players often come up with entirely new folding strategies. "There's this incredible amount of human computing power out there that we're starting to capitalize on," says Baker, who is feeding some of the best human tactics back into his Rosetta algorithms.

By harnessing human brains for problem solving, Foldit takes BOINC's distributed-computing concept to a whole new level. And it is not alone: several projects are emerging in this field, sometimes called distributed thinking, and the number of publications based on the approach is increasing.

"We're at the dawn of a new era, in which computation between humans and machines is being mixed," says Michael Kearns, a computer scientist at the University of Pennsylvania in Philadelphia, who evaluated the concept of distributed thinking as part of an unpublished 2008 study funded by the US Defense Advanced Research Projects Agency. Kearns says that the approach has the most promise



got tired of the idea that everything has to have an acronym," he says laconically.

Anderson's intention is that Bossa will always be open source and free, so that any scientist can use the software and adapt it to the task at hand. He foresees applications as diverse as in the BOINC ecosystem, where 68 active projects are engaging nearly two million users worldwide.

An early recruit is Tim White, a UCB palaeontologist, whose research involves searching for early hominid fossils in the Great Rift Valley of east Africa. For decades, his teams have searched in the same way: slowly. Bent over. Crawling across the dry desert soil in temperatures of up to 50 °C. But with their planned Bossa-based project, which they intend to call Hominids@home, much of that work could be taken over by volunteers who would look for the white gleam of bone in pictures. "A kid in front of a monitor isn't going to know the difference between the tooth of a colobus monkey and a baboon," says White, "but they're going to know it's a tooth."

Galaxy Zoo

The online astronomy project Galaxy Zoo, which launched in 2007 at the University of Oxford, UK, is taking a rather different tack. Co-founder Chris Lintott says that the project was directly inspired by Stardust@home. "If people would look at dust grains," he says, "then surely they'd look at our beautiful images of galaxies" — images that have been collected in the millions by the international Sloan Digital Sky Survey consortium.

The idea is for volunteers to determine by eye whether the galaxies are spiral or elliptical — a task for which computers are almost worthless. Galaxy Zoo has already published 17 papers after classifying 1.25 million different galaxies, and has just begun another stage of galaxy classification with data from the Hubble Space Telescope.

But as Lintott expands his domain to a 'Zooniverse' of projects — not just for galaxy classification, but for galactic mergers, supernovae, solar storms and lunar craters — he has been much pickier than Anderson is being with Bossa, where anyone can try anything. Lintott worries that Bossa projects might be hasty affairs that end up wasting the goodwill of citizen scientists. "Rather than letting anyone pitch for volunteers, we'd like to be a place where people can come and expect a certain level of commitment," he says.

Anderson, not surprisingly, disagrees. He says he likes the commitment of Galaxy Zoo to distributed thinking, but not its 'walled garden' approach. Galaxy Zoo "doesn't provide flexibility to the individual scientist", he says.

Baker says that he also drew his inspiration for Foldit from Stardust@home. But any similarities to that program or to Galaxy Zoo end there. For one thing, Foldit players aren't just engaged in basic image recognition and classification tasks — they are intuitively solving much harder optimization problems. Baker argues that the program is exploiting three uniquely human talents: a superior spatial awareness; an ability to take short-term risks for long-term gain; and the converse, recognizing a dead-end early and knowing when to quit.

> "It needs to be an exciting, compelling experience that's not always the same."

The other important difference is that the Foldit designers take the gaming element more seriously. Neither Galaxy Zoo nor Stardust has the immersive qualities of Foldit, with its chat rooms, wikis and increasingly difficult levels of play. Zoran Popović, Baker's computer-science collaborator at the University of Washington, points out that holding the volunteers' interest is necessary if they are to learn quickly the skills required to make a real contribution. "It needs to be an exciting, compelling experience that's not always the same," says Popović.

There are also limits to games. If nothing else, says Kearns, as human computing becomes ubiquitous, "people will no longer marvel at being a part of these networks and may start to feel exploited by them". The day may come when scientists have to seduce volunteers by doing what many consider anathema at present: paying them. "There will be a whole economics of this field," says Kearns.

S. ZACCANELLI

Scott Zaccanelli designed a fibronectin variant that was synthesized in the lab.

For now, there are still plenty of volunteers who are not jaded. Scott 'Boots' Zaccanelli is one of them. A resident of McKinney, Texas, he splits his time between a day job as a buyer for a valve factory and a personal business — Good For You Massage Therapy — that takes him and his massage chair to rodeos, county fairs and flea markets. But he has also been hooked on Foldit since 2008. "I'm pretty much there every night," says Zaccanelli, who has used his undergraduate biology degree to help him rise to a number-6 global Foldit ranking. "I can look at something and see that it's not right."

The skills of players such as Zaccanelli are so impressive that Baker has moved past protein folding and is now offering them chances to design completely new proteins. Tasks include searches for new catalysts for photosynthesis, and for proteins that can bind to pathogens such as HIV or the H1N1 influenza virus.

One puzzle asked players to create a more stable variant of fibronectin, a protein scaffold that is useful for creating antibody-like compounds. Last October, Baker thought Zaccanelli's design was promising enough to be synthesized in the lab — the first time a player's recipe had been tested. It turned out that Zaccanelli's fibronectin wasn't any more stable, but Baker says it is just a matter of time before a player designs something that is.

And that is a good enough motivation for Zaccanelli. "Maybe something I do will help contribute an answer to curing cancer or AIDS or the common cold," he says. ■

Eric Hand is a reporter for *Nature* in Washington DC.

People power

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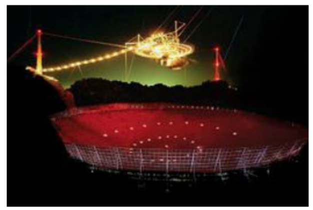
News

Home computer finds rare pulsar

The Einstein@Home volunteer-computing project makes its first discovery.

Eugenie Samuel Reich

A rare isolated pulsar with a very low magnetic field has been discovered by a volunteer-computing initiative, researchers report today in the journal *Science*[1].



Data gathered by the world's largest radio dish in Arecibo, Puerto Rico, is later sifted for puslars by the *Einstein@Home* project.

Louie Psihoyos/Science Faction/Corbis

When Bruce Allen, director of the Einstein@Home distributed-computing project, first contacted Chris and Helen Colvin from Ames, Iowa, to tell them that their home computer had made a significant discovery while running the project's software as a screensaver, they did not believe he was serious. The Colvins are among 262,000 volunteers in 192 countries who have loaded and run the **Einstein@Home** software on their computers.

"This is the first time an astronomical object has been discovered by this kind of distributed-computing project," says Allen, a director of the Max Planck Institute for Gravitational Physics in Hannover, Germany. "I'm really excited we found something."

Like its better known counterpart, **SETI@home**, Einstein@Home uses the time when volunteers' computers are idle to crunch through massive data sets looking for patterns. Whereas SETI@home searches through radio observations for signals of possible extraterrestrial intelligence, Einstein@Home sends out data from the Laser Interferometer Gravitational Wave Observatory to be analysed for the presence of gravitational waves.

After a four-year search for gravitational waves drew a blank[2], Allen decided to dedicate 35% of Einstein@Home's computing time to searching for signals from pulsars — collapsed neutron stars that emit beams of radiation along their axis as they spin — in radio observations taken at the Arecibo Observatory in Puerto Rico. "Searching for gravitational waves is a long-term proposition and I thought it would be fun for Einstein@Home volunteers to have something that could be found at a rate of one or two a year," says Allen.

The first of the new data were sent out in March 2009, and in June, the Colvins' computer scored a hit: the detection of a previously unknown pulsar that was emitting a radio pulse at a rate of 41 per second, faster than 90% of known pulsars. Three days later, the pulsar was redetected by

NATURE **| NEWS**

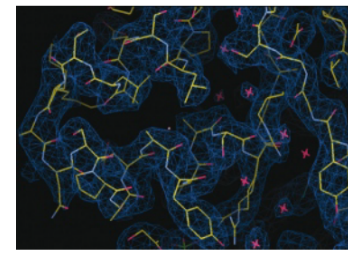
Victory for crowdsourced biomolecule design

Players of the online game Foldit guide researchers to a better enzyme.

Jessica Marshall

22 January 2012

Obsessive gamers' hours at the computer have now topped scientists' efforts to improve a model enzyme, in what researchers say is the first crowdsourced redesign of a protein.



An enzyme designed by players of the protein-folding game Foldit was better than anything scientists could come up with.

The online game Foldit, developed by teams led by Zoran Popovic, director of the Center for Game Science, and biochemist David Baker, both at the University of Washington in Seattle, allows players to fiddle at folding proteins on their home computers in search of the best-scoring (lowest-energy) configurations.

The researchers have previously reported successes by Foldit players in folding proteins[1], but the latest work moves into the realm of protein design, a more open-ended problem. By posing a series of puzzles to Foldit players and then testing variations on the players' best designs in the lab, researchers have created an enzyme with more than 18-fold higher activity than the original. The work is published today in *Nature Biotechnology*[2].

"I worked for two years to make these enzymes better and I couldn't do it," says Justin Siegel, a post-doctoral researcher working in biophysics in Baker's group. "Foldit players were able to make a large jump in structural space and I still don't fully understand how they did it."

The project has progressed from volunteers donating their computers' spare processing power for protein-structure research, to actively predicting protein structures, and now to designing new proteins. The game has 240,000 registered players, 2,200 of whom were active last week.

The latest effort involved an enzyme that catalyses one of a family of workhorse reactions in synthetic chemistry called Diels-Alder reactions. Members of this huge family of reactions are used throughout industry to synthesise everything from drugs to pesticides, but enzymes that catalyse Diels-Alder reactions have been elusive. In 2010, Baker and his team reported that they had designed a functional Diels–Alderase computationally from scratch[3], but, says

CAREERS

SEQUESTRATION Slashed budgets may put non-tenured US researchers at risk **p.261** p.261

EUROPEAN UNION Proposed law would make researchers more mobile **p.261**

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JEROME LEWIS/EXCITES

Hunter-gatherers in the Congo Basin are using smartphones to track poaching and logging.

CITIZEN SCIENCE

Amateur experts

Involving members of the public can help science projects — but researchers should consider what they want to achieve.

BY TRISHA GURA

Equipped with smartphones, computers and do-it-yourself sampling kits, lay volunteers are tweeting about snowfall, questing for comets and measuring the microbes in their guts. They are part of a growing group of 'citizen scientists', networks of non-scientists who help to analyse or collect data as part of a researcher-led project. They learn about science and get a chance to participate, but the scientists involved stand to gain too. "There is huge amount of spare attention out there and a huge desire to do something real with it," says Christopher Lintott, an astronomer at the University of Oxford, UK, and chair of the Citizen Science Alliance, which hosts projects and advises researchers.

There are indications that in the past five years or so, citizen science has become more popular with researchers — and more likely to translate into a legitimate, publishable research project. It offers a means of doing substantial, thoughtful public outreach, and of tackling otherwise intractable, laborious or costly research problems.

But recruiting non-scientists comes with complications, including finding the right technical tools and partners to organize and execute projects with potentially thousands of data collectors. And scientists must ensure that the data are sound. Researchers thinking about entering the citizen-science fray should contact established associations for guidance and consider what they want from the end result — is it outreach alone, or something more?

It is difficult to measure the growth in citizen science accurately, in part because many ventures overlap with science-education efforts, but projects are definitely becoming more common. The Citizen Science Alliance began with one project in 2007 and has now hosted more than 20. The alliance has received 200 proposals for possible projects in the past year alone, and launched 10. A similar organization called SciStarter now boasts more than 450 projects. Citizen Science Central — co-founded by Rick Bonney, an ornithologist at Cornell University in Ithaca, New York, who in 1995 coined the term citizen science — lists 162 projects.

Some have given rise to peer-reviewed publications. Jake Weltzin, an ecologist at the University of Arizona in Tucson, is executive director of the USA National Phenology Network, which runs a project called Nature's Notebook. Citizen scientists track how climate affects the timing of life-cycle events in plants and animals. Weltzin's group jumped from one publication in 2007 — when citizen science elsewhere meant asking for access to people's computer-processing power to work with huge amounts of data — to more than 100 now. "This is a whole new way of doing science," says Weltzin. "Being able to think about and collect data at a continental scale."

STRENGTH IN NUMBERS

Citizen science can help researchers to address previously insoluble problems. For example, Justin Halberda, a psychologist at Johns Hopkins University in Baltimore, Maryland, wanted to study how cognition develops as people age. He originally thought that he would need to gather data from tens of thousands of people of all ages over the course of years, a feat that would be financially and logistically impossible for one research team with a limited budget.

So he reached out, asking volunteers to play a sort of video game that measures number sense — the ability to estimate how many items there are in a collection without actually counting them. The game involved watching yellow and blue dots flash briefly on a screen, then estimating whether there were more yellow or blue. Over the course of a few months, more than 13,000 individuals — ages 11 to 85 — took the test, and Halberda's team analysed the results.

The researchers not only built up a general description of people's number sense, but also unveiled a surprise: individuals don't achieve the best precision in number sense until ▶

to search for transit events — brief dips in the brightness of stars that occur when planets pass in front of them. To track how well citizen scientists can spot transits, and to measure the sensitivity of the system to different kinds, the Planet Hunters team inserts fake planet signals alongside the genuine data and measures how good people are at detecting them. In another quality-control measure, multiple users do the same task on the same data, so that mistakes are averaged out. And because users log in to use the system, the researchers can track which citizen scientists are best at which tasks and then give extra weight to results from the best performers.

The sheer scale of the projects can create quality-control challenges. The eBird project at Cornell uses citizen scientists to document the presence, absence and abundance of species across the United States. It receives 25 million observations a month, which are reviewed by a team of 500 volunteers, handpicked for their experience. Each reviewer must sift through 4% of the observations to validate them, in essence looking at hundreds of thousands of observations. Project organizers are currently thinking about new ways to manage the big data sets, by either reviewing less or automating more.

"You are getting the information that you need at the same time that you are getting people involved."

Scientists also have to face the challenge of recruiting volunteers and keeping them engaged. "The science has to be romantic, in a way, so that people want to support the research behind it," says Jason Osborne, president and co-founder of Paleo Quest, a citizen-science organization focused on palaeontology. Projects have to be interesting, tangible and involve discovery, he adds. In an offshoot of Paleo Quest called SharkFinder, for example, Osborne and co-founder Aaron Alford identify layers of rock riddled with shark fossils and take large samples from river swamps and other remote environments. The researchers then distribute the samples in kits to US classrooms. Any fossils that students discover are sent to the University of Maryland in College Park, where palaeontologists led by Bretton Kent verify the findings. The project currently samples fossil formations along the east coast of the United States, but Osborne hopes to expand his sampling work to Panama and other countries. "You put Panama in the kit, and kids are like, 'Wow, I have a piece of Panama on my desk, and I am looking for fossil remains,'" says Osborne, noting that kids also love handling prehistoric fossils. "There has got to be that kind of wow factor." And if they discover a new species, Osborne's citizen scientists might be named on a publication — or even be given the opportunity to name the species.

Whatever a volunteer's motivation — even if it is just the joy of participating — scientists have to understand and nurture it. For Old Weather, Brohan's team came up with a ranking system. Citizens receive the title of cadet when they join. After transcribing 30 pages of logs, they are promoted to lieutenant. The person who transcribes the most pages on a ship becomes the captain. Social media and online forums le

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from the Harvard Forest area in Massachusetts to the entire eastern seaboard of the United States. The team published its expanded model this year (S.-J. Jeong *et al.* *Geophys. Res. Lett.* 40, 359–364; 2013). Not only did peer reviewers welcome the citizen-science data, but one actually gave advice on how to use the citizen-science model more effectively, says Weltzin.

If all goes well, citizen science is a way to communicate science, engage in outreach and accomplish research aims. "You are getting the information that you need at the same time that you are getting people involved," says Weltzin. "It is like playing Whack-a-Mole with all hammers out. You meet all of your objectives at one time." ■

Trisha Gura *is a freelance writer in Boston, Massachusetts.*

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CORRECTED 16 APRIL 2013 |

Public policy plays an influential role in the work we do as HCI researchers, interaction designers, and practitioners. "Public policy," a broad term, includes both government policy and policy within non-governmental organizations. This forum focuses on topics at the intersection of human-computer interaction and public policy. **— Jonathan Lazar, Editor**

Sharing Data While Protecting Privacy in Citizen Science

Anne Bowser, University of Maryland and Woodrow Wilson International Center for Scholars Commons Lab, **Andrea Wiggins,** Cornell Lab of Ornithology and University of New Mexico, **Lea Shanley,** Woodrow Wilson International Center for Scholars Commons Lab, **Jennifer Preece,** University of Maryland, **Sandra Henderson,** Project Budburst

Imagine finding a flower you haven't seen before, or watching the first swallows arrive in your garden each spring. How would you record and share this data with those who can advance science or shape public policy? Every day, millions of "citizen scientists" participate in research to support real-world goals [1]. eBird volunteers contribute natural observations of birds that ultimately inform land conservation policies (http://ebird.org). Players of Foldit, an online game for citizen science, helped to identify a protein crucial to the reproduction of HIV (http://fold.it).

Traditional scientific research has well-established rules and procedures, such as informed consent, to ensure the privacy and security of individual participants. In contrast, citizen science projects frequently are created by community members who come together with shared concerns, such as air pollution or loss of habitat. These projects use data contributed by members of the public. Consequently, citizen science practices and the technologies that support them may be designed without privacy in mind. But in these cases, as with scientific research, protecting participant privacy should still be a key concern.

Consider a hypothetical example: Track-a-Tree (TaT) is a popular online citizen science project that asks people to find a deciduous tree and report its seasonal changes. Individuals register their tree and its location online. Participants submit observations and photos of each tree to the TaT website. TaT has an open access policy, so all data is freely available.

TaT is concerned that personal information about participants may become available on its website. In addition, uploaded photographs may include recognizable people, depicting whom they were with and where they were. TaT could have legal problems if such im of children) are pub proper permissions

Because each tre made public, TaT st their database may locations of particip schools, workplaces of worship. This co others with malicio to find participants reveal sensitive info participants' affiliat educational project ensure that childre guided by a respons

While TaT is a hy project, many of th including safety fro and stalking, the co of personal informa

liberties relating to the protection of individual privacy—are very real. Here we define privacy as "the right to manage access to voluntarily submitted personal data." Personal data refers first to personally identifiable information (PII). As defined by the Office of Management and Budget, PII includes information that can distinguish an individual (such as full name) and information

inaturalist.org). Scientists use research grade data from iNaturalist, while volunteers use the platform to manage their own data, explore others' observations, and interact through direct messaging or following one another's online activity.

Through these examples, we explore legal and policy

Insights

→ Citizen science projects must protect the privacy of volunteers by informing them about potential threats and implementing safeguards.

→ Privacy laws, policies, and standards exist to guide developers of citizen science applications toward best practices.

LAW	DESCRIPTION	APPLIES TO
The Children's Online Privacy Protection Act (COPPA)	The online collection of personal information from children under 13	Many projects, especially those with an educational component
Health Insurance Portability and Accountability Act (HIPAA)	Protects the privacy of medical records	Projects in health
Privacy Act	Restricts federal agencies from collecting, using, or distributing PII	Projects funded by federal agencies
The Freedom of Information Act (FOIA)	Guarantees citizens access to records maintained by the federal government; protects PII from public record	Projects funded by federal agencies
E.U.'s Directive on Privacy and Electronic Communications	Websites must clearly state data collection practices, including cookies	Projects doing business in the E.U.

→ Table 1. U.S. federal privacy laws.

CITIZEN SCIENCE

Next Steps for Citizen Science

Strategic investments and coordination are needed for citizen science to reach its full potential.

Rick Bonney,[1]† Jennifer L. Shirk,[1] Tina B. Phillips,[1] Andrea Wiggins,[2,1] Heidi L. Ballard,[3] Abraham J. Miller-Rushing,[4]* Julia K. Parrish[5]

Around the globe, thousands of research projects are engaging millions of individuals—many of whom are not trained as scientists—in collecting, categorizing, transcribing, or analyzing scientific data. These projects, known as citizen science, cover a breadth of topics from microbiomes to native bees to water quality to galaxies. Most projects obtain or manage scientific information at scales or resolutions unattainable by individual researchers or research teams, whether enrolling thousands of individuals collecting data across several continents, enlisting small armies of participants in categorizing vast quantities of online data, or organizing small groups of volunteers to tackle local problems.

Despite the wealth of information emerging from citizen science projects, the practice is not universally accepted as a valid method of scientific investigation. Scientific papers presenting volunteer-collected data sometimes have trouble getting reviewed and are often placed in outreach sectio
or education tracks of scientifi
the same time, opportunities to
ence to achieve positive outcom
and society are going unreali
offer suggestions for strategic t
izen science practitioners and
peers—and for tactical investm
funders and government agen
the field reach its full potential.

Training for data-gathering. Women from Komo (Republic of the Congo) learning to map in the forest, as part of the Extreme Citizen Science (ExCiteS) Intelligent Maps project.

science projects, along with scientific reports

tion possible for groups that previously were

Strategic investments and coordination are needed for citizen science to reach its full potential.

Transformed by Technology

Although citizen science is som
ered a recent phenomenon, ama
have studied the world for mo
history (*1*). Much of our curre
ing about our natural environm
the effects of climate change, is derived from data that have been collected, transcribed, or processed by members of the public. During the past two decades, the number of citizen

ence projects that can be accomplished only online. Many are data-processing projects for which participants classify or interpret sound files, videos, or pictures, such as the millions of images of galaxies, moon craters, and seafloor organisms that have been categorized by participants in various projects operated through Zooniverse.

Citizen science also has been enhanced by statistical tools and computational techniques that remove many of the barriers to compiling and analyzing complex data sets. Computers and accessible interfaces have made participa-

from eBird have been used in at least 90 peer-reviewed articles and book chapters covering topics in ornithology, ecology, climate change, and statistical modeling (*6*). Zooniverse projects have yielded more than 50 peer-reviewed articles on topics ranging from galaxies to oceans (*7*). And many environmental protection agencies use volunteer water- and air-quality data to target streams and neighborhoods for protection.

Understanding the scientific impact of citizen science can be challenging because of the spectrum of projects that are referred to

[1]Cornell Lab of Ornithology, Cornell University, Ithaca, NY 14850, USA. [2]DataONE, University of New Mexico, Albuquerque, NM 87106, USA. [3]School of Education, University of California, Davis, CA 95616, USA. [4]National Park Service, Schoodic Education and Research Center and Acadia National Park, Winter Harbor, ME 04693, USA. [5]School of Aquatic and Fisheries Sciences, University of Washington, Seattle, WA 98195, USA. *The views expressed in this paper do not necessarily represent the views of the Department of Interior or the U.S. Government. †Corresponding author. reb5@cornell.edu

Mapping for Change (Extreme Citizen Science at UCL, UK)

NATURE | NEWS

Citizen science goes 'extreme'

Researchers push for wider use of community-generated data in science and policy-making.

Katherine Rowland

17 February 2012

In the Congo Basin, Bayaka pygmies patrol their forests with handheld tracking devices. Using the devices to record instances of poaching, industrial roads and illegal logging, they map their landscape, documenting the course of deforestation and harmful development.

Cameroon Baka in the Nki National Park map their territory using handheld Global Positioning System devices to track illegal logging and poaching.

JOHN NELSON/FOREST PEOPLES PROGRAMME

The project is part of an emerging field that its champions describe as the 'new wave' of citizen science. With endeavours ranging from air-pollution assessments in Europe to chimpanzee counting in Tanzania, the next generation of citizen science attempts to make communities active stakeholders in research that affects them, and use their work to push forward policy changes. This is one of the main points of focus of the London Citizen Cyberscience Summit being held this week at the Royal Geographical Society and University College London.

Although researchers have been calling on amateurs and enthusiasts for decades to aid in collecting and processing large volumes of data, the latest approaches aim to enlist the public in helping to shape research questions, says Francois Grey, a physicist at Tsinghua University in Beijing and coordinator of the Citizen Cyberscience Centre in Geneva, Switzerland. Grey, an organizer of the summit, maintains that communities can play a valuable part in setting the agenda for scientific investigations.

Muki Haklay, a geomatic engineer and co-director of the newly formed research group Extreme Citizen Science (ExCiteS) at UCL says that what makes the approach ‘extreme‘ is the vastly expanded definition of public participation. Prior citizen-science projects have tapped into the computing and creative capacity of volunteers, who have tended to be a self-selecting and highly educated group. One of Haklay’s central objectives is to develop methodologies that enable communities — regardless of socioeconomic or educational status — to ask research questions and collect and analyse data to advance local interests.

Working in Deptford, UK, Haklay and his colleagues set up a community initiative to monitor the noise pollution

_IDEAS

TRIBUNA
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Ciencia ciudadana o ciencia de guerrilla

Por Josep Perelló

La participación ciudadana es pieza esencial de lo que hoy recibe el nombre de ciencia ciudadana. La publicación de los resultados científicos y su divulgación llegan con dificultad a la sociedad: se trata pues de involucrar al ciudadano de manera directa en la investigación. Contribuyendo a proyectos de ciencia ciudadana, el *amateur* quiere pasarlo bien, aprender y, en su versión más extrema, crear conocimiento de impacto inmediato en su cotidianidad.

tros centros de investigación: datos abiertos, validación de datos, programación de *apps*, privacidad, comunicación, visualización de datos, diseño gráfico, gestión de comunidades, propiedad intelectual entre muchos otros flancos. La ciencia ciudadana debe pues ubicarse en marcos abiertos que contemplen alianzas ágiles y flexibles.

El científico tiene que también cuidar minuciosamente sus lazos sociales con distintos colectivos y comunidades para garantizar el éxito de un proyecto. Se piensa en el tejido asociativo y una *app* para multiplicar la participación en el proyecto Riu.net que mapea la calidad ecológica de nuestras cuencas fluvia-

Abejas Urbanas es un proyecto ubicado en el Museo de Ciencias Naturales de Barcelona. /E. M.

nocimiento. Por crear políticas transparentes y democráticas con el conocimiento adquirido. Al fin y al cabo, pa-

«Si no queremos que sea una moda hay que empoderar al ciudadano con conocimientos nacidos de sus manos»

“Un experimento de laboratorio es un artefacto raro, costoso, local y artificial.”

Bruno Latour