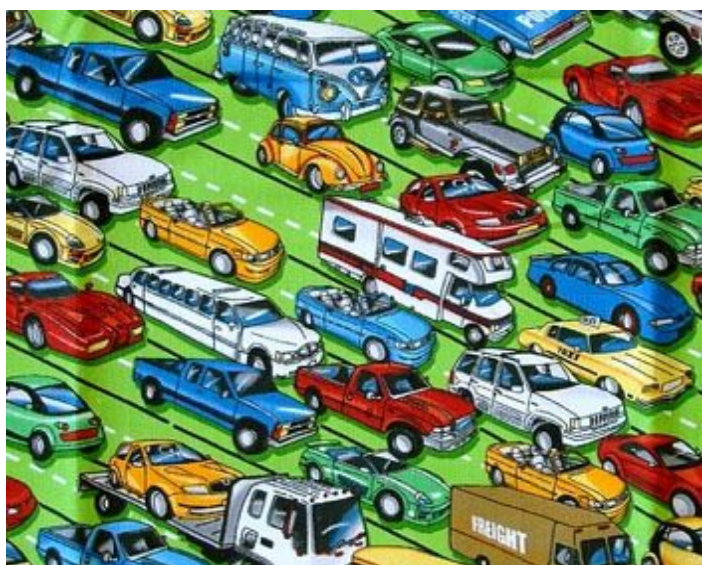


物理故事

交通堵塞的物理学

学物理的人常会产生一些奇特联想。比如水在适当条件下会出现所谓的“过冷”现象 (supercooling)，温度低于冰点而不结冰，但只要稍加扰动或掺入杂质，就会快速凝结成冰。最近几个月，我每天上下班在某高速公路上开几十分钟的车，渐渐地，注意到了有一个有趣的现象：那高速公路通常是畅通的，但稍有干扰都不行，小雪、小



雨、小雾，甚至一辆警车停在路旁，都常能使它堵塞得一塌糊涂。每当我的车子陷入那样的堵塞之中时，我就会恨恨地联想起过冷水的凝结来。

原以为这不过是自己的奇特联想，却不料这些天打算以交通堵塞作为本期专栏短文的题材时，一查资料，居然发现有关交通堵塞的流行理论包含了这一联想。

我们从头说起吧。自汽车的大规模使用开始，交通堵塞这一现代社会的顽疾就不曾离开过我们，对它的研究也因此有了一段不算太短的历史。在这种研究中，一个很流行的视角就是将车流与水流相类比。早在 20 世纪 50 年代，英国流体力学专家莱特希尔 (James Lighthill) 与应用数学家惠瑟姆 (Gerald Whitham) 就提出了一个模型，将高速公路上的车流类比于水管中的水流。这一模型被称为莱特希尔-惠瑟姆模型 (Lighthill-Whitham model)，是许多后续研究的基础。20 世纪 90 年代初，德国物理学家奈格尔 (Kai Nagel) 和施莱肯伯格 (Michael Schreckenberg) 等人推进了这种类比，在他们的模型中，司机的行为被抽象为了几条主要特征：比如司机会努力维持与前方车辆的安全距离；比如安全距离是随车速的增加而增大的。这些特征符合几乎所有司机的行车习惯，从而是很合理的。通过这样的模型，奈格尔等人发现当车流密度达到某个临界值之后，车流的速度会明显减缓，也就是说会发生交通堵塞。

这是一个不错的结果，可惜却太规律了一点，从而不足以说明如

司机会倾向于尽量维持自己的车速。在这一假定下，奈格尔等人发现，当车流密度超过临界值时，由于司机们维持自己车速的顽固意愿作祟，车流仍会保持较高的速度。但那样的车流将逐渐失去稳定性，各种偶然因素，比如道路缺陷、天气因素乃至某位司机的刹车踩得太重，都会被快速放大并导致交通堵塞。这一结果正是本文开头所提到的交通堵塞与过冷水的凝结这一物理现象间的相似性。交通堵塞与物理现象间的相似性还不止于此。奈格尔等人的模型——经过与现实数据的比较——虽然对交通堵塞作出了较好的描述，却也并非尽善尽美。更细致的考察发现，现实的车流中除了畅通和堵塞之外，还有一种很常见的状态，就是所有车子都以大体相同的速度缓缓行驶。20 世纪 90 年代末，这种被称为“同步” (synchronized) 的状态被俄裔德国科学家科纳 (Boris Kerner) 等人

吸收进了一个新的模型。在这种模型里，车流与水流的类比走得更远：正如水有汽、水和冰三种状态，车流也有畅通、同步和堵塞三种状态；而且正如汽的结冰通常要经过“水”这一中间状态，交通状态由畅通到堵塞也通常会经过“同步”这一中间状态。这种模型被称为“三相交通理论” (three-phase traffic theory)，也引起了一些人的关注。

这些有关交通堵塞的研究由于其与物理学的相似，而被一些人称为“交通物理学” (traffic physics)。“交通物理学”虽还处在发展阶段，却已有了许多应用。就拿交通堵塞与过冷水的凝结之间的相似性来说，它所显示的交通堵塞与偶然因素之间的密切关联可以启示人们关注一些看似细微的东西，比如司机踩刹车过重的情形。研究表明，只要消除 20% 的司机踩刹车过重的情形，就能显著改善道路通行状况。在这方面，开发自动或半自动的驾驶技术或许是大有可为的。除这种微观应用外，交通物理学还可以有更宏观的应用，比如预言交通堵塞的发生，并将结果实时提供给司机，以起到预警及避免堵塞的作用。

(文章选自卢昌海个人主页)

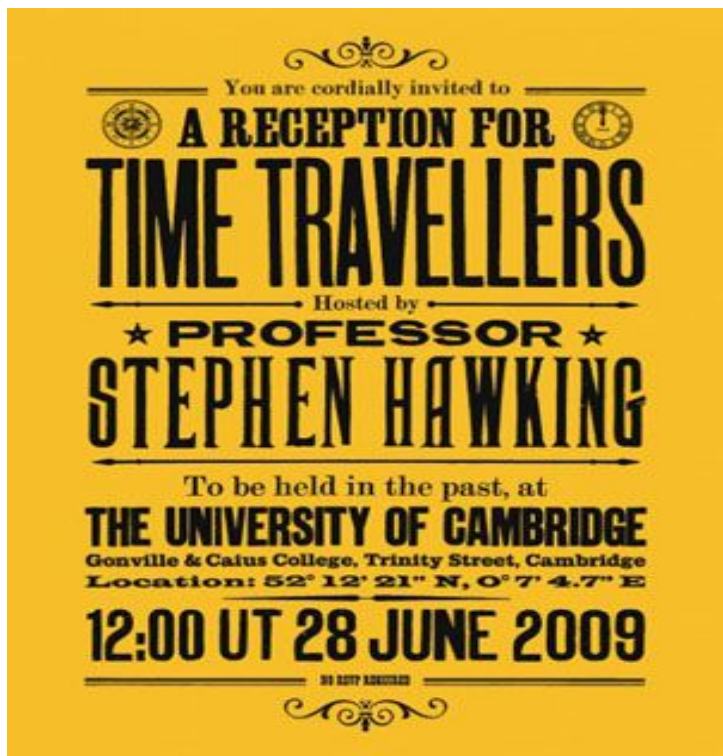
霍金的派对

每个人一生都会遇到遗憾事，如果你是电脑游戏玩家，也许常常会希望人生能像电脑游戏那样“读取进度”，让憾事不再。如果你问物理学家：人生能否“读取进度”？也许他会告诉你：那得看时间旅行是否可能。

时间旅行是否可能？这问题物理学家们从目前已知的物理规律入手进行过研究，初步的结果不容乐观，但尚无定论。既然尚无定论，就存了可能性，因此，有些物理学家从另一个角度进行了探讨，即时间旅行如果可能，我们周围是否已经有了时间旅行者？英国物理学家霍金 (Stephen Hawking) 在《时间简史》(A Brief History of Time) 一书中就问过这个问题，他并且提出，对这个问题的否定回答，也许意味着重返过去的时间旅行是不可能的——之所以强调“重返过去”，是因为时间旅行在目前显然还不可能，从而时间旅行者只能来

自未来，到我们周围对他们来说乃是重返过去。

为了检验我们周围究竟有没有时间旅行者，霍金还做过一个有趣的实验：他给时间旅行者写了请柬，邀请他们于某个指定时间到剑桥



大学内的某个指定地点参加派对。他并且把消息的发布安排在指定时间之后，以确保没有普通人能因提前知道消息而冒充时间旅行者，那请柬则被放在了一个能长久保存的地方，以便未来很长时间的内的时间旅行者都有可能发现它们。

结果，没有任何人来参加霍金的派对。

不过物理学家们并不死心。2013年，美国密歇根理工大学（Michigan Technological University）的物理学家奈米罗夫（Robert J. Nemiroff）等人想到了另外一招：在互联网上搜索时间旅行者的信息。什么样的信息能被认为是来自时间旅行者的呢？奈米罗夫等人认为是有“先见之明”（prescient）的信息。具体地说，他们考虑了两类那样的信息：一类是在2012年9月之前提及“Comet ISON”（ISON彗星）的信息；另一类是在2013年3月之前提及“Pop Francis”（教皇方济各）的信息。这两者的时间范围都选在了所涉及的术语问世之前，因此对那些术语的提及有可能是时间旅行者才能有的“先见之明”。对那两类信息的选取还考虑了另外一些因素：比如所涉及的术语比较独特（这可以减少巧合），且比较重要（这可以增加其被时间旅行者知晓的可能性——不过“Comet ISON”在我看来是不太够格的）。

至于搜索手段，奈米罗夫等人所倚重的是“推特”（Twitter）网站的具有时间排序的搜索功能，同时也借鉴了对他们的目的来说有一定缺陷的“谷歌”（Google）、“面簿”（Facebook）等网站的搜索功能。此外，他们还利用了“谷歌趋势”（Google Trends）——一种针对搜索术语本身的搜索工具，以检验是否有人在那些术语问世之前就进行过有先见之明的搜索。

搜索的结果则跟霍金的派对一样：一无所获。虽然搜索失败，但

相对于其他手段，网络搜索是比较容易的，因此或许会有人效仿。不过，那样的搜索有多大可信度却是值得怀疑的。日本推理作家东野圭吾的小说中，有位罪犯在若干意外事件发生之前就在网上发布了信息。按奈米罗夫等人的方法，那样的信息很可能被当成是时间旅行者才有的“先见之明”。而其实，罪犯手法的环节之一只不过是发布很多同类信息，以确保有些能碰对。在奈米罗夫等人的搜索中，自然不会有罪犯来搅局，但每天有那么多人发布那么多信息，哪怕是比较独特的术语，碰巧出现的可能性也是不容忽视的。事实上，奈米罗夫等人已经碰到了一例，只不过是以太过含糊为由丢弃了。此外，这种搜索的遗漏性是很大的，因为重要术语何止成千上万？时间旅行者恰好提及被选中的术语的可能性是极小的。

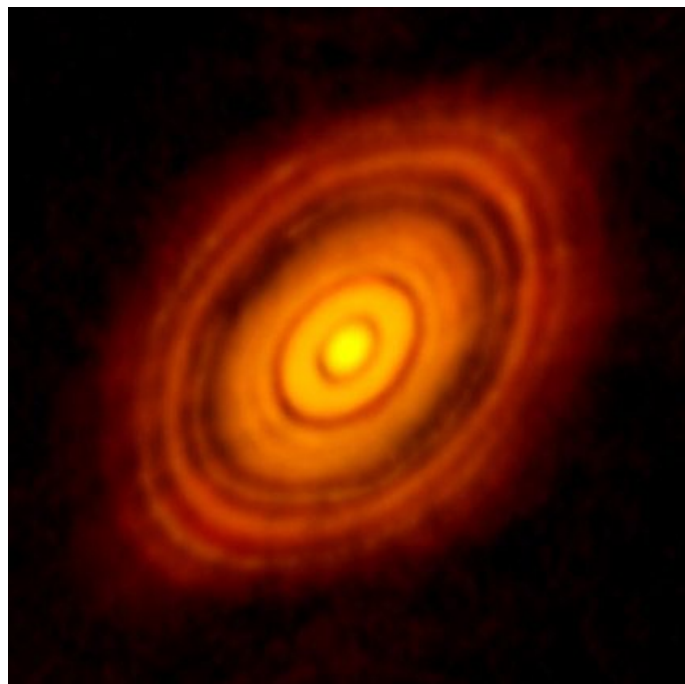
更何况，若时间旅行者果真来到我们周围，且有能力和意愿展示他们的先见之明，他们会用提及一两个术语那样小儿科的手法吗？我是很怀疑的。我倒是想起了多年前读过的一篇科幻小说：一艘来自先进文明的飞船因失事而致一名乘员失踪，那失踪之谜最终被查清了，原来那乘员幸存在了地球上，他在地球上的名字叫做爱因斯坦！

也许，那篇科幻小说的寓意还更切实一些吧，因为未来的科技才是最确凿的先见之明，时间旅行者若不吝展示先见之明的话，他（她）完全有可能成为像爱因斯坦那样的大人物，而不是在网上发几个含糊其辞的术语。

（文章选自卢昌海个人主页）

新图像呈现行星形成惊人画面

美国国家射电天文台表示，宇航员捕捉到了一张让人震惊的行星形成图像，该行星围绕一颗叫作 HL Tau 的年轻恒星运行。当一颗新恒星



形成时，其自身会塌缩，产生大量的灰尘和残骸，然后这些尘埃和残骸会逐渐合并成行星。由于行程中的行星会围绕恒星运转，它们会把自身轨道周围的残骸清理干净，从而出现上图中的暗色环，形成一个叫作原始行星盘的结构。

数学快递

Stock market models help researchers predict animal behavior

Date: November 12, 2014

In an unexpected mashup of financial and mechanical engineering, researchers have discovered that the same modeling used to forecast fluctuations in the stock market can be used to predict aspects of animal behavior. Their work proposes an unprecedented model for in silico -- or computer-based -- simulations of animal behavior. The findings were published in the Journal of the Royal Society Interface.

The team, led by Maurizio Porfiri, professor of mechanical and aerospace engineering and director of the school's Dynamical Systems Laboratory, is more accustomed to studying the social behavior of zebrafish -- a freshwater species often used in experiments due to its genetic similarity to humans. Porfiri has drawn considerable attention for his interdisciplinary research on the factors that influence zebrafish collective behavior.

However, designing procedures and conditions for animal experiments are time-intensive, and despite careful planning, many experiments yield mixed data. Porfiri and his team, comprising postdoctoral fellow Ross P. Anderson, doctoral student Violet Mwaffo, and former postdoctoral fellow Sachit Butail (now assistant professor at Indraprastha Institute of Information Technology Delhi), set out to develop a mathematical model of animal behavior that could predict the outcome or improve the effectiveness of experiments and minimize the number of fish used in them.

When mapping the movement of zebrafish as they swam, Porfiri and his colleagues observed that the species does not move in a continuous pattern; rather, it swims in a signature style characterized by coasting periods followed by sharp turns. As they plotted the turn rate of the fish over time, the

researchers noticed that their data, with its small variations followed by large dips (reflecting fast turns), looked very different from the turn rate of other fish but very similar to another type of data, where such volatility is not only common but well studied: the stock market.

The team embraced the mathematical model known as a stochastic jump process, a term used by financial engineers and economists to describe the price jumps of financial assets over time. Using many of the same tools employed in financial analysis, the researchers were able to create a mathematical model of zebrafish swimming, mining video footage from previous experimental sessions to seed what they hope will become a robust database of zebrafish behavior under varying circumstances.

"We realized that if we could simulate the swimming behavior of these fish using a computer, we could test and predict their responses to new stimuli, whether that is the introduction or removal of a shoal mate, the presence of a robotic fish, or even exposure to alcohol," Porfiri said. "In behavior studies, you can easily utilize thousands of test subjects to explore different variables. This will allow researchers to replace some of that experimentation with computer modeling."

Porfiri emphasized that this mathematical model of animal behavior will also allow researchers to make better use of their data following experiments, not just beforehand. "The data that result from zebrafish experiments look quite messy initially," Porfiri said. "Giving researchers a model they can use to compare, filter, and refine their analysis afterwards will allow them to maximize data for better results."

Porfiri and his team plan to continue to add data to their model with the hope of creating a toolbox that all researchers engaged in this field of study can utilize.

The idea of incorporating financial engineering to model zebrafish behavior came from Mwaffo, now a doctoral student in Porfiri's lab who had earned his master's degree in financial engineering from the NYU Polytechnic School of Engineering.

Source: New York University Polytechnic School of Engineering

From: <http://www.sciencedaily.com/releases/2014/11/141112120158.htm>

When vaccines are imperfect: What math can tell us about their effects on disease propagation



The control of certain childhood diseases is difficult, despite high vaccination coverage in many countries. One of the possible reasons for this is "imperfect vaccines," that is, vaccines that fail either due to "leakiness," lack of effectiveness on certain individuals in a population, or shorter duration of potency.

In a paper publishing in the SIAM Journal on Applied Mathematics, authors Felicia Magpantay, Maria Riolo, Matthieu Domenech de Celles, Aaron King, and Pejman Rohani use a mathematical model to determine the consequences of vaccine failure and resulting disease dynamics.

"We examined the effects of individual-level vaccine failure on the propagation of a disease through a population," says author Felicia Magpantay. "Specifically, we took into account different ways in which vaccines may fail. We distinguished between vaccine-induced immunity that is 'leaky', whereby vaccination reduces the probability of infection upon exposure but does not eliminate it; 'all-or-nothing', which leads to perfect protection in some individuals, but none in others; and 'waning', which reflects transient protection--or some combination of all three."

While leakiness, degree and duration of coverage have direct effects at the individual level, the protection from imperfect vaccines and reduced disease transmission at the population level is not easy to determine. "By carefully ensuring a like-with-like comparison of the differences in the mechanism of vaccine failure, we identified distinct epidemiological signatures at the population-level and explored their implications for disease control," Magpantay explains.

The group of professional applied mathematicians considers a systematic analysis based on the "susceptible-infectious-recovered" model used in epidemiological studies. This model allows one to calculate the number of susceptible, infectious and recovered individuals in a population, factoring in infection and recovery rates as well as contact between susceptible and infected individuals. The authors adapt this model with an added vaccine component to compare the dynamics of the three aforementioned types of imperfect vaccines.

The critical proportion of the model population that needs to be vaccinated in order to drive the disease to extinction is seen to be the same in all three cases. When vaccination coverage is maintained below the critical ratio, the disease remains endemic in the population at a higher level for leaky vaccines, compared to the other two imperfect vaccines. "Among vaccines that exhibit the same level of individual-level effectiveness, the purely leaky vaccine always leads to the highest prevalence of infection in the long run. The purely all-or-nothing and purely waning vaccines lead to the same levels of prevalence," Magpantay elaborates.

The authors then extend their ordinary differential equation model to account for age distribution in the population using a system of partial differential equations for age-specific transmission. "The age distribution of the infected class depends on the type of vaccine failure, the age-specific contact rates and the vaccine coverage. In the cases that we have considered, the waning vaccine leads to the highest mean age of first infection," Magpantay says.

The authors also show that the three imperfect vaccines have distinct transient dynamics following the initiation of vaccination in a population. "Numerical simulations suggest that vaccination with leaky and waning vaccines can bring about a long honeymoon period: a temporary period of low disease prevalence after the onset of mass vaccination," Magpantay explains. "This provides an alternative explanation for the observed resurgence of some diseases like pertussis in regions that maintain high vaccination coverage." All-or-nothing vaccines appear to show a more stable transition.

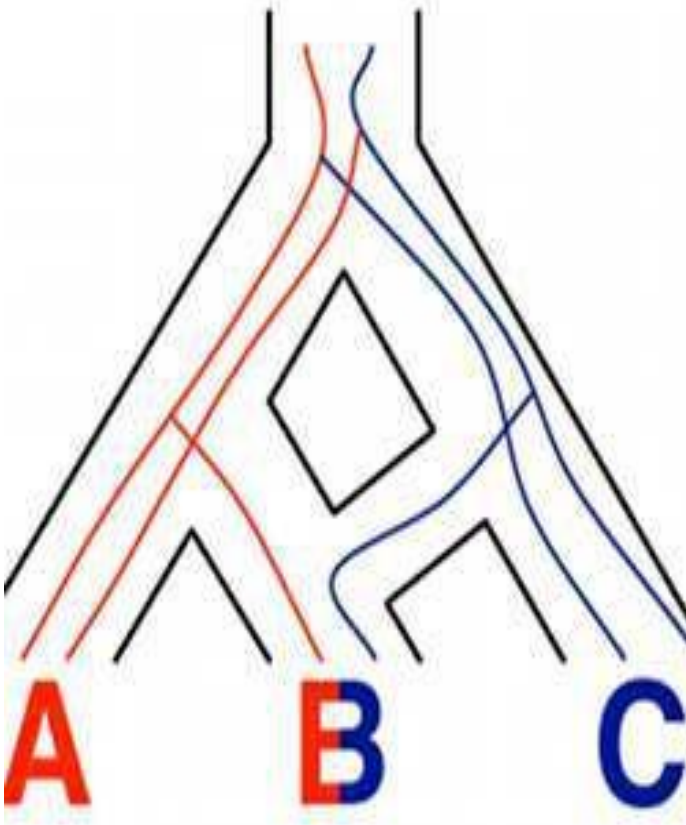
Topics for future work include examining the role of seasonality on transmission rates as well as the effect of a vaccine on infectiousness of an individual.

Source: Society for Industrial and Applied Mathematics

From: <http://www.sciencedaily.com/releases/2014/11/141120183602.htm>
 计科突破

Evolution Software Looks Beyond the Branches

November 19, 2014



Software by scientists at Rice University aims to reveal far more about species' evolutionary histories than traditional tree models can.

Credit: Luay Nakhleh/Rice University

Rice University researchers have developed PhyloNet, an open source Java-based program that accounts for both the horizontal and vertical inheritance of genetic material among genomes.

The researchers also have developed a "maximum likelihood" method that enables PhyloNet to infer network models that better describe the evolution of certain groups of species than do tree models.

Inferring means analyzing genes to determine their evolutionary history with the highest probability of connections between species. The software infers the probability of variations that phylogenetic trees cannot illustrate, such as horizontal gene transfers, which circumvent simple parent-to-offspring evolution and enable genetic variations to move from one species to another by means other than reproduction.

"We are the first group to develop a general model that will allow biologists to estimate hybridization while accounting for all these complexities in evolution," says Rice researcher Luay Nakhleh.

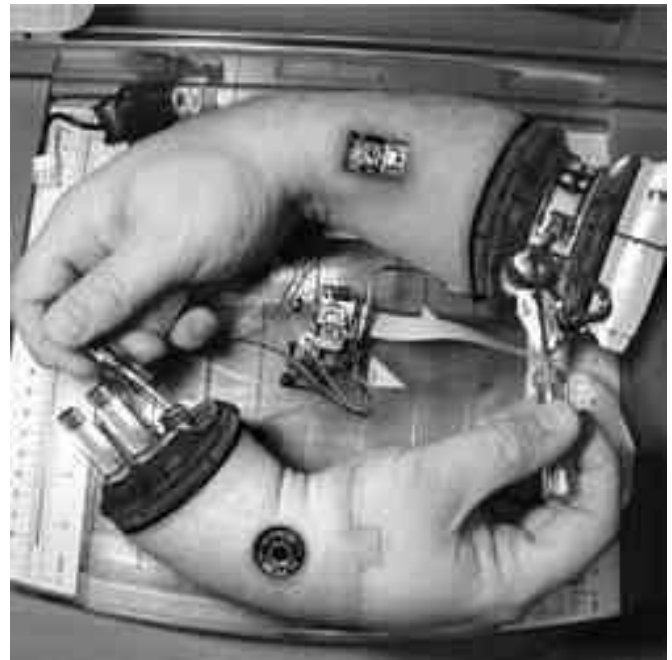
The researchers used two data sets to test the program. One was a computer-generated set of data that mimics a realistic model of evolution and enabled the researchers to evaluate the accuracy of the program, while the other involved multiple genomes of mice found across Europe and Asia.

From Rice University

Self-Repairing Software Tackles Bugs

November 17, 2014

Researchers at the University of Utah have developed a software suite that can detect and eliminate malware from computers running the Linux



operating system.

Credit: emeryblogger.com

University of Utah researchers have developed the Advanced Adaptive Applications (A3) software suite to detect and eliminate malware. They say A3 instantly repairs damage and prevents malware from infecting the computer again.

A3 works with a virtual machine that emulates the operations of a computer without dedicated hardware. The software is designed to monitor a virtual machine's operating system and applications, notes University of Utah professor Eric Eide. A3 is intended to protect servers or similar business-grade computers that run on the Linux operating system, along with military applications.

There are no plans to adapt A3 for home computers or laptops, but Eide says this could be a possibility in the future.

A3 can detect new, unknown viruses or malware automatically by sensing that something is occurring in the computer's operation that is not correct. A3 stops the virus, determines a repair for the damaged software code, and learns to permanently block that malware from entering the machine.

To test A3's effectiveness, a team from the university and Raytheon BBN used it against the Shellshock malware. A3 was able to discover Shellshock on a Web server and repair the damage in four minutes, while six other pieces of malware also were successfully handled by A3, Eide notes.

From *University of Utah News*

'Flight Simulator' for Surgeons: Project Joins Computer Science With Medicine

November 14, 2014

University of Wisconsin-Madison investigators are working on the



development of a surgical simulator as a teaching tool.

Credit: Sarah Morton

University of Wisconsin-Madison investigators are developing a simulator to help medical students virtually practice surgical procedures.

Professor Eftychios Sifakis is collaborating with professor Timothy King, as well as with Dr. Court Cutting, an international expert in cleft lip and palate procedures, and computer sciences graduate student Nathan Mitchell.

In early November, the team used the tool to demonstrate how to make and close incisions on flat areas of skin, make scalp incisions, and suture them using flap techniques.

The simulator emphasizes biomechanical accuracy. Surgeons must predict how soft tissue will respond to a procedure based on factors such as age, type of tissue, and its location on the body. The simulator's three-dimensional renderings eventually will demonstrate how real skin will react under actual conditions, which will require further development as well as the acquisition of more information about live tissues. Sifakis says the end goal is to create an agile, portable system for use on tablets or other mobile devices.

The U.S. National Science Foundation is funding the team's efforts through its three-year Smart and Connected Health grant awarded in July 2014. The researchers say the simulator has significant potential to curb errors and post-surgical complications.

From *University of Wisconsin-Madison*

News

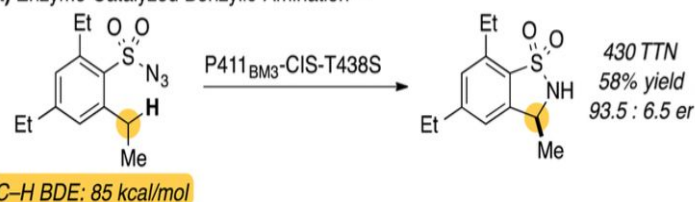
化学视角

Enzymes And Metals Enable Regiodivergent Organic Reactions

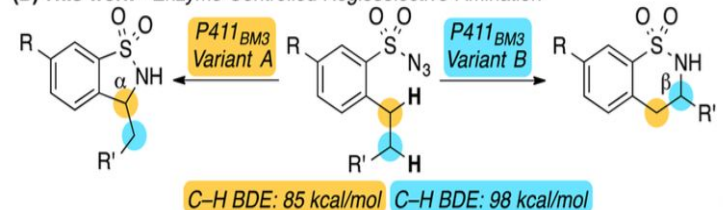
By Stephen K. Ritter

Divergent regioselectivity, in which the same reaction can lead to different products depending on the catalyst and reaction conditions, is a particular challenge for synthetic organic chemists. Two research teams have reported findings that provide new insight on how to make directional selectivity a little easier. Frances H. Arnold and coworkers at California Institute of Technology engineered two variants of a cytochrome P450BM3 enzyme to control nitrogen atom transfer and enable regiodivergent C–H aminations. One enzyme favors ring-closing amination at the α -position of an alkyl substituent on a benzene sulfonyl azide. The other enzyme favors amination at the β -position (*J. Am. Chem. Soc.* 2014, DOI: 10.1021/ja509308v). Meanwhile, Chao-Jun Li's group at McGill University, in Montreal, has discovered a selectivity switch in ring-forming coupling reactions between

(A) Enzyme-Catalyzed Benzylic Amination¹¹

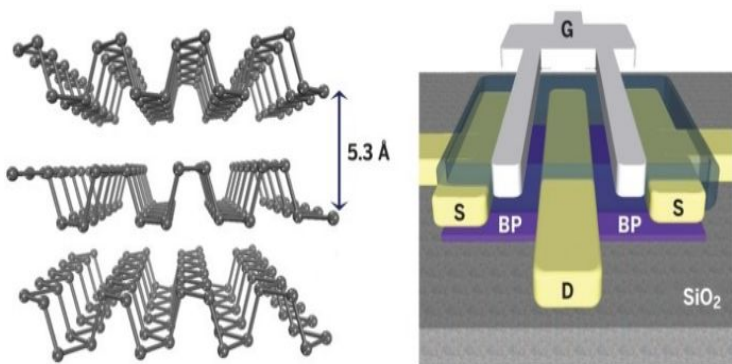


(B) This work - Enzyme-Controlled Regioselective Amination



2-hydroxybenzaldehydes and terminal alkynes. With a gold catalyst, the researchers obtain an isoflavanone skeleton, whereas a rhodium catalyst produces a coumarin skeleton (*Angew. Chem. Int. Ed.* 2014, DOI: 10.1002/anie.201407589). According to the researchers, enzymes represent a versatile platform for solving selectivity problems in organic synthesis, either through synthetic biology or through inspiration to develop metal-catalyst enzyme mimics.

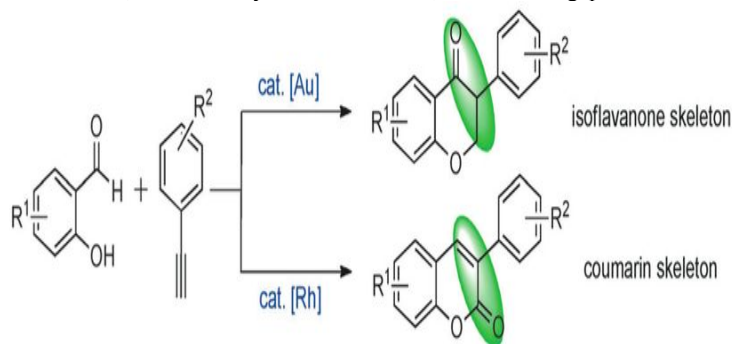
Researchers Try Out A New Thin-Film Material For Transistors
By Katherine Bourzac



Thin-film materials such as graphene and molybdenum disulfide show promise for making flexible electronics. But so far, none of these materials has hit the sweet spot of electrical properties needed to compete with silicon. Now researchers have shown that films of black phosphorus can be used to make radio-frequency transistors, components found in many telecommunication devices (Nano Lett. 2014, DOI: 10.1021/nl5029717).

Black phosphorus, the most stable form of the element at room temperature, has a structure that looks like a wrinkled version of graphite. Although black phosphorus has been known for a long time, it wasn't until this past year that researchers started exploring the use of the material for electronics.

Han Wang, an electrical engineer at the University of Southern California, says researchers are excited about black phosphorus because, unlike other two-dimensional materials, it both has a band gap and conducts charge fairly well. A material with a band gap can be switched between conducting and insulating states, lending devices such as transistors well-defined on and off states. This produces high-quality signals and saves power when the transistor is off. Materials with high charge mobility conduct charges well, and transistors made with them can switch on and off rapidly. Graphene has no band gap, but it does have superlative charge mobility. Meanwhile, other 2-D materials, such as molybdenum disulfide, have a band gap but have low



charge mobility.

On the basis of what they and other researchers recently have learned about the material, Wang, Fengnian Xia of Yale University, and their colleagues built transistors made from a few layers of black phosphorus. These transistors can operate in the gigahertz range, switching on and off 20 billion times per second. Their performance is similar to that of transistors used in radio-frequency telecommunications circuits, such as those found in cell phones. Those transistors are made from silicon and other rigid semiconductors.

To make the devices, the researchers mechanically cleaved bulk black phosphorus into flakes. They selected flakes 6 to 10 nm thick and placed them on silicon wafers topped with a layer of silicon dioxide. To complete the transistors, they then used conventional methods to grow metal electrodes and a gate. The new transistors were quite large, about 300 nm wide. Simulations run by the team predict that if they can shrink the devices to 50 nm or smaller, the transistors should operate above 100 GHz.

Many challenges remain for developing black phosphorus electronics, Wang says. For example, researchers need to find ways to grow large-area thin films of the material because working with flakes is not practical.

But the new report shows that it's worth taking the time to solve these

problems, says Wei Ji, a physicist at Renmin University of China who published one of the early papers describing the electrical and optical properties of black phosphorus films. Such high performance with a first attempt, he says, "suggests the huge potential of black phosphorus gigahertz transistors."

生科发现

1. 2014年11月21日《科学》杂志精选

2014-11-21 www.bio360.net 来源: 生物360 作者: koo 381 0

封面故事: 探索皮肤

Exploring the skin

在一个人手皮肤的极端特写。《科学》推出特刊探讨了哺乳动物皮肤健康和疾病的生物学基础。



赶在流感病毒演变之前制备更好的疫苗

Antibody landscapes after influenza virus infection or vaccination

一项新的研究显示,以未雨绸缪的方式来接种针对未来可能的流感病毒株的疫苗而不是接种针对已经在人群中流行的病毒株疫苗可能效果更好。这一知识可帮助科学家们让某种已经有效的疫苗变得更为有效。流感病毒是一种富有挑战性的可用疫苗进行对抗的病毒。在任何一段时间都有许多不同病毒株在流行,它们中的每一株都能快速演化,但疫苗制造商必须要提前几个月的时间知道将哪种病毒株放入季节性流感疫苗中。如今,应用一种新研发的被称作抗体景观模型的电脑技术, Judith Fonville 等人可直接看到针对流感病毒的保护性反应与那些流感病毒躲避免疫攻击反应之间的相互作用。他们在接触流感病毒感染并接种流感病毒疫苗达6年的个人中对这些反应进行了追踪,揭示了每个人独特的免疫反应概貌(还有免疫记忆领域和未受保护区域)。他们研究的一个关键发现是,一旦感染,所看到的不仅是一个只针对感染中流感病毒株的反应,而是看到针对该个体已经遭遇的所有流感病毒株的反应。他们说,因此,未雨绸缪地更新某疫苗株可刺激针对未来感染病毒的更好保护,且不会以损害针对目前流行病毒所产生的保护作用作为代价。他们的结果不仅显示为什么接触新的病毒株可增强免疫反应,而且还提示了一种可优化未来疫苗接种计划的途径。一篇《视角》文章提出了更多的见解。

在小鼠体内揭示了 HIV 药物的意想不到的好处

Nucleoside reverse transcriptase inhibitors possess intrinsic anti-inflammatory activity

一项在小鼠中的新的研究显示,一类被称作核苷逆转录酶抑制剂(NRTIs)的大众化 HIV 药物可有效地治疗诸如视网膜变性及移植物抗宿主病等疾病。据研究人员披露,该类药物的这些先前未被认识到的治疗裨益与他们阻断 HIV 中的逆转录能力——这是一种可阻止该病毒从其基因组进行复制的作用——无关,而这可赋予 NRTIs 双重用途,使得它们符合药物再利用的条件。Benjamin Fowler 和同事对 NRTI 司他夫定以及某些其它目前由联邦食品与药物管理局批准用于治疗 HIV 的 NRTIs 进行了仔细观察并发现,这些药物可防止由一种被称作 NLRP3 炎性体大型蛋白复合物引起的炎症。这种由 NLRP3-介导的炎症通常是由非编码的逆转录酶触发的,这些逆转录酶像 HIV 那样依赖逆转录酶来完成它们的生命周期——而这种炎症过去被证明会杀死视网膜细胞并促成黄斑变性。Fowler 等人如今披露,NRTIs 可阻断一种叫做 P2X7 的离子通道的活性,而这反而会压制 NLRP3 炎性体。他们发现,多种 NRTIs 对治疗肝脏炎症、移植物抗宿主疾病以及两种形式的年龄相关黄斑变性的小鼠模型有效。他们说,也有一种可能就是这种对炎性体的抑制性活性促成了 NRTI 对 HIV 的治疗作用。

人类需要有大麦才能到达世界屋脊 Agriculture Facilitated Permanent Human Occupation of the Tibetan Plateau after 3,600 BP

研究人员说,人们是在西方谷物——尤其是大麦到来时才在海拔 3000 米的青藏高原上建立永久居住地的。尽管有证据显示,人们在该地区的间歇性定居可追溯到至少 2 万年前,但 Fahu Chen 和同事说,人们直到大约 5200 年前才在那里——即所谓的“世界屋脊”——站稳脚跟。而那些早期人类定居者只是在 3600 年前才知道如何在海拔 3000 英尺之上生存下来,因为他们说,当时一个跨越大陆的农作物移动给西藏高原带来了大麦、小麦及其它西方谷物。十分有趣的是,研究人员还提出,这一向上的迁徙发生在地球正在变冷的时候。Chen 以及一个国际性研究小组对来自青藏高原东北地区各地的 53 处遗址的动物骨骼、植物遗骸及其它人工制品进行了研究,旨在描绘一幅该地区早期人类定居的画面。他们采样的大部分遗址代表了沿着黄河及其支流的早期农耕定居点。研究人员发现,这些最早人类定居主要是由小米——如狐尾粟和糜子——维持的,而它们仍然位于海拔 2500 米之下。他们说,接着,在大约 3600 年前,膳食大多由大麦组成的人类定居点开始向上移动至高达 4700 米的高度。研究人员提出,这些早期定居者可能是为搜寻猎物所驱而到西藏高原的一但调换成来自西方的主要农作物——它们比小米更耐寒——使得他们能在地球的屋脊建立永久性的家园。

2. 2014 年 11 月 20 日《自然》杂志精选



2014-11-20 www.bio360.net 来源:生物 360 作者:koo 678 0 封面故事:“Mouse ENCODE Consortium”联合项目组的 4 篇论文

小鼠是生物医学研究中最好的模型生物。为了获得关于共同的和物种特异性的转录和细胞调控程序的更多信息,名为“Mouse ENCODE Consortium”的联合项目组在各种不同细胞和组织类型中对整个小鼠基因组内的转录、DNase I 超敏性、转录因子结合、染色质修饰和复制域进行了分析绘。这些发现被与人类的相应数据进行比较,从而证实在新注解的潜在功能序列中存在很大程度上的保守性,也揭示了在转录调控、染色质状态和高层次染色质组织中所涉及的其他序列的显著差异。这些数据和它们所做的分析为研究哺乳动物生物学和人类疾病的机制提供了一个宝贵的资源。本期 Nature 发表了 4 篇来自该项目组的论文,另外在一篇 News & Views 文章中 Piero Carninci 还对该项目组所获得的数据集将会怎样帮助我们了解人类生物学及生物医学问题进行了分析。封面: Kelly Krause/ Nature。

(doi: 10.1038/nature13992 & doi: 10.1038/515346a & doi: 10.1038/nature13972 & doi: 10.1038/nature13985 & doi: 10.1038/nature13986)

由 RNA 控制的 DNA 修复

如其名称所示,通过同源重组进行的 DNA 修复一般被认为发生在两个 DNA 分子之间。然而,研究工作已经证明, RNA 也可用在人造环境中。Francesca Storici 及同事现在发现,内源 RNA 转录体能够与酵母染色体 DNA 的重组。这一结果说明,遗传信息在细胞中从 RNA 向 DNA 的直接流动也许要比我们过去所认为的普遍得多,而且因为细胞核中的 RNA 水平非常高,所以这些结果也许会让人们对修复的可塑性和基因组不稳定性机制有新的认识。(doi: 10.1038/nature13682)

针对 Ral GTPase 的小分子抑制剂

通过 Ras GTPase 通道进行的信号传导在癌症中经常过度活跃, Ras 通道的组成部分作为潜在癌症治疗目标也正在受到广泛研究。在这项研究中, Dan Theodorescu 及同事采用一个基于结构的方法发现了能够选择性地以 Ral GTPase (Ras 信号传导的一个重要下游中介物)为目标的小分子抑制剂。这些抑制剂在 Ral 的不活跃状态与其结合,在细胞分析和在小鼠中通过生化方式得到了表征。这些第一代抑制剂将是阐释 Ras 信号传导的宝贵工具,也将是朝着开发用于癌症治疗的 Ral 特异性药物的方向所迈出的一步。(doi: 10.1038/nature13713)

疟疾入侵蛋白的结构

每种疟原虫都含有至少一种“网状细胞结合蛋白同源物”(RH)蛋白,该蛋白与“红细胞结合蛋白”(erythrocyte binding-like protein)一起在红细胞入侵(疟原虫生命周期中的一个关键步骤)中起一定作用。镰刀形疟原虫的“网状细胞结合蛋白同源物-5”(PfRH5)与红细胞表面蛋白 basigin 发生相互作用,并且已被认为是一个有希望的疫苗候选物。在这篇论文中, Matthew Higgins 及同事描述了与 basigin、同时也与抑制性抗体形成复合物的 PfRH5 的晶体结构。该结构显示了具有风琴样架构的一个折叠,在一个端部有供 basigin 和抗体使用的结合点。

(doi:10.1038/nature13715)

在无序中建立有序

近几十年来,“共轭聚合物”受到关注。它们是以共价键结合的有机大分子,含有骨架结构,结合了塑料材料的柔韧性和可加工型以及半导体材料的电学特性。但高分子材料在天然状态下趋于无序,而这种无序最终限制了其电子性能。Deepak Venkates 及其同事发现一些性能较好的共轭聚合物尽管微观结构处在无定形状态,但它们的电子特性实际上与有序状态相似。借助计算机模拟,作者找到了这种意外“非无序”特性的分子起源,并提出了如何将其设计到其他共轭聚合物体系中的方法。

(doi: 10.1038/nature13854)

一种“左右逢源”的核酶

人们普遍假设,同手性是对生命的一个要求,生物大分子必须是同样的立体化学手性才能高效地发生相互作用。通过与 Leslie Orgel 和其他人合作, Gerald Joyce 在 1984 年对这一思想进行了延伸,提出同手性也可能是生命起源所必需的,因为 RNA 模板化的多聚反应很容易在同手性系统中发生,但在外消旋混合物中则会受到影响。现在, Joyce 及本

文共同作者 Jonathan Sczepanski 发现,相反手性的 RNA 能够一起合作。他们设计出一种 d-RNA 酶,这种酶能催化 L-RNA 在一个 L-RNA 模板上的多聚反应,反之亦然。这种核酶的催化效能足以使其能够通过将 11 个作为组成成分的寡核苷酸连接起来合成其自己的对映异构体。该核酶被认为通过第三接触点而不是通过沃森-克里克碱基对与其基质发生相互作用。这一出乎意料的发现将为关于生命是怎样在一个“RNA 世界”中出现的观点增添一个新的维度。(doi: 10.1038/nature13900 & doi: 10.1038/nature13935)

琥珀酸盐在缺血性心脏病中所起作用

在对缺血性心脏所做的这项代谢组学研究中, Michael Murphy 及同事识别出驱动活性氧簇的生成、对“缺血再灌注损伤”有贡献的一种代谢物。他们发现,琥珀酸盐在几种组织中是缺血的一个保守的代谢特征。琥珀酸盐因名为“琥珀酸脱氢酶”的酶的逆转而在缺血过程中积累。在再灌注时,积累的琥珀酸盐被迅速氧化,通过“线粒体复合物-I”上的反向电子传输驱动活性氧簇的生成。琥珀酸盐积累的药物阻断在心脏病发作和中风的小鼠模型中会改善“缺血再灌注损伤”的状况。

(doi: 10.1038/nature13909 & doi: 10.1038/nature13941)

植物的一个双时钟系统

生物时钟系统帮助很多生物使其生理活动适应每天的和季节性的环境变化。对哺乳动物来说,时钟系统有双重性质:“视交叉上核”中的一组神经元起中央主导性时钟的作用,调控周围组织中的局部时钟。相比之下,人们长期以为,植物节律在所有细胞中都是相等的。现在, Motomu Endo 等人提供的证据证明,植物也有一个双重时钟系统。通过利用两个新的多功能方法对拟南芥叶子组织进行详细分析,作者发现,在维管组织内,时钟具有与在其他组织内截然不同的特点,而且维管时钟也影响其他组织内的时钟调控。(doi: 10.1038/nature13919 & doi: 10.1038/nature13936)

农业发展会增加大气二氧化碳的季节性变化

大气二氧化碳记录显示了反应陆地植被二氧化碳吸收情况季节性变化的一个季节性周期。过去 50 年这一季节性周期幅度的增加目前还无法完全得到解释。现在,两个小组报告,农业的集约化可能是大气二氧化碳季节幅度增加的一个关键贡献因素。Ning Zeng 等人利用 VEGAS 陆地生物圈模型显示,中纬度农业生产力的增强,为 1961 年到 2010 年间全球净表面碳流量幅度的增加做出了 45% 的贡献,相比之下来自气候变化的贡献为 29%,来自二氧化碳施肥作用的贡献为 26%。Josh Gray 等人利用来自联合国粮农组织的作物生产统计数字和碳会计模型显示,大气二氧化碳季节性中所观测到的变化的多达 1/4 可以由作物生产力的提高得到解释,其中玉米、小麦、水稻和大豆是主要贡献因素。这些研究将有助于更好地了解全球碳循环,也显示了人类行动正在改变生物圈-大气层的大规模相互作用的程度。(doi: 10.1038/nature13893 & doi: 10.1038/515351a & doi: 10.1038/nature13957)

新型 2D 纳米材料的新颖性质

二维材料会具有与三维材料明显不同的性质,这个现象长期以来都受到深入研究。在这篇论文中, Beatriz Noheda 及同事通过建立用于二维材料合成的一条不同寻常的路径(这条路径能够产生独特的化学环境和新颖的功能——在该研究中这种新颖功能就是一种复合氧化物中的磁性),从而将这个概念提升到了一个新层次。作者以取向附生方式在钛酸锶上生长亚锰酸铽,并通过应变工程在铁电畴壁内产生了与材料其余部分截然不同的化学性质和磁性性质。铁电畴壁充当纳米尺度的化学反应器,以促进具有异常化学性质和磁性性质的相的形成。这一方法应当可以应用于其他复合氧化物,从而获得可应用于纳米电子和自旋电子系统的新型纳米材料。(doi:10.1038/nature13918 & doi: 10.1038/515348a)

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孙准教授课题组致力于计算机模拟在材料科学中的应用。采用量子化学方法、分子力场、分子动力学和蒙特卡罗模拟方法,这些方法能够预测材料的物理和化学性质。

课题组大部分的工作都是基于力场技术。孙准教授 1998 在 J. Phys. Chem. B 上发表了题为:‘COMPASS: An ab Initio Force-Field Optimized for Condensed-Phase Applications Overview with Details on Alkane and Benzene Compounds’的论文,至今已被引用 1900 多次。课题组在此基础上开发了一套可迁移,可扩展,准确和模块化的力场,称为 TEAM 力场,探索如何从 TEAM 力场出发来开发粗粒化力场,并在 ReaxFF 框架下开发反应

力场。

为了获得可靠的模拟数据,课题组应用并发展了多种加强采样的技术,如加速分子动力学和副本交换分子动力学。这在模拟溶液中的化学反应和表面活性剂/聚合物自组装过程中有着重要的应用。

课题组目前关注的性质有:复杂流体,如表面活性剂、聚合物和离子液体的热力学性质;凝聚相中的化学反应;小分子气体在多孔材料,如沸石和 MOFs 中的吸附、扩散和分离过程。

无论是数学、物理、化学、计算机还是生物方向的同学都可以加盟孙准课题组哦~

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