CAREERS

SKILLS SCULPTOR Lab head teaches what people really need to know **p.371**

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AGUSTINA ISIDORI

Games, such as the chemistry card game *Science Ninjas: Valence*, can teach concepts interactively.

ENTERPRISE

Game on

Scientists are designing board, card and digital games to convey scientific concepts.

BY ROBERTA KWOK

Dante Lauretta loves board games — so much so, he has always wanted to create one. He often plays them with his two sons and suggests new rules. "It's always been a dream of mine to design a board game," he says.

Lauretta, a planetary scientist at the University of Arizona, Tucson, got his chance in 2013. He was leading OSIRIS-REx, NASA's effort to return an asteroid sample to Earth, when the mission's education and public outreach programme was cancelled. Undeterred, he co-founded Xtronaut Enterprises in Falls Church, Virginia, to produce activity kits about planetary exploration and science. When the children started trading the flash cards of rocket components, he realized he could turn the cards into a game.

He designed the board game *Xtronaut: The Game of Solar System Exploration*, in which players try to launch space missions. In 2015, Lauretta and his team raised nearly US$37,000 on the crowdfunding site Kickstarter to produce the game; the first 5,000 copies sold out, and the company made 5,000 more. This year, Xtronaut Enterprises raised about $43,000 on Kickstarter for a second game, *Constellations*. The games haven't made Lauretta rich, but his goal is to inspire kids. "I've got parents telling me their five-year-old daughter knows all about Delta second stages and fairings and Delta-V," all technical rocket terms, he says. "If just that one little girl has learned that, I'm happy."

A growing group of scientists like Lauretta, many of whom are avid gamers, are creating board, card and digital games for children and adults to engage with science. Games offer interactivity, and designers say that they are an underused medium to convey technical concepts. For instance, players can navigate the ramifications of climate change or battle antibiotic-resistant bacteria. The games can raise scientists' profiles, and a few researchers have become full-time game developers.

Their success reflects a broader trend: independent game development has exploded over the past decade. Since Kickstarter launched in 2009, about 11,000 successful game campaigns from 20 countries have raised roughly $600 million (see 'The rise of indie games'). Game-building software tools such as Unity from Unity Technologies in San Francisco, California, have made it easier to create digital games. The site BoardGameGeek.com now lists about 91,000 board and card games, and Apple's App Store offers more than half a million game apps.

Science games still occupy a tiny niche. ScienceGameCenter.org, which allows teachers, students and other users to find and review science and maths games for ages 10 and up, contains about 120 entries. But the number has grown steadily since the site launched in 2012, says director Melanie Stegman, a biochemist and owner of Molecular Jig Games in Washington DC. And support for these games has emerged with new contests, funding and events.

But scientists who want to ride the indie-game-development wave should proceed with caution. Designers must balance accuracy with simplicity and fun. And selling board games involves mundane logistics such as printing and shipping; digital games often require time-consuming development. The costs of designing and launching a game range from about ten thousand to hundreds of thousands of dollars, which researchers must raise through channels such as crowdfunding and outreach grants.

To succeed, says Lauretta, a scientist should want to play the game they're designing. "You've got to be a kid at heart."

SMART DESIGN

Several groups around the world provide support for science games. The Center for Research and Interdisciplinarity in Paris started the International Game Competition for Education and Research (iGAMER) in 2013, and at Climate Game Jams, developers gather, ▶

mainly in the United States, to crank out climate-change-related game prototypes. And this year, six teams received funding from Developing Beyond, a contest held by the charitable foundation Wellcome in London and Epic Games in Cary, North Carolina, in which teams create games about topics such as plant engineering; the competition will award a total of $500,000.

> ***"I wanted a game where you have to make real strategic decisions."***

Modern science games often encourage players to think deeply about concepts. In the past, many educational games resembled *Trivial Pursuit* or involved rolling a die and moving around a board, says David Coil, a microbiologist at the University of California, Davis. "They're just not that fun," he says. "I wanted a game where you have to make real strategic decisions." So he designed the board game *Gut Check*, in which the goal is to build a healthy microbial community, or microbiota (D. A. Coil *et al. PLoS Biol.* **15,** e2001984; 2017). Players must ponder whether to eat certain foods, add bacteria to their guts or give opponents infections.

Scientists can uncover design flaws by testing prototypes with family, friends, gamers at meet-ups and students. For instance, in *Gut Check*, a 'faecal transplant' card allows players to eliminate pathogens; to prevent the card from being too powerful, Coil decided it would also deduct a few of the player's health points. But during testing, he realized that a player could kill an opponent by giving them multiple faecal transplants, which didn't make sense biologically. So he changed the rules so that players could use the card only on themselves.

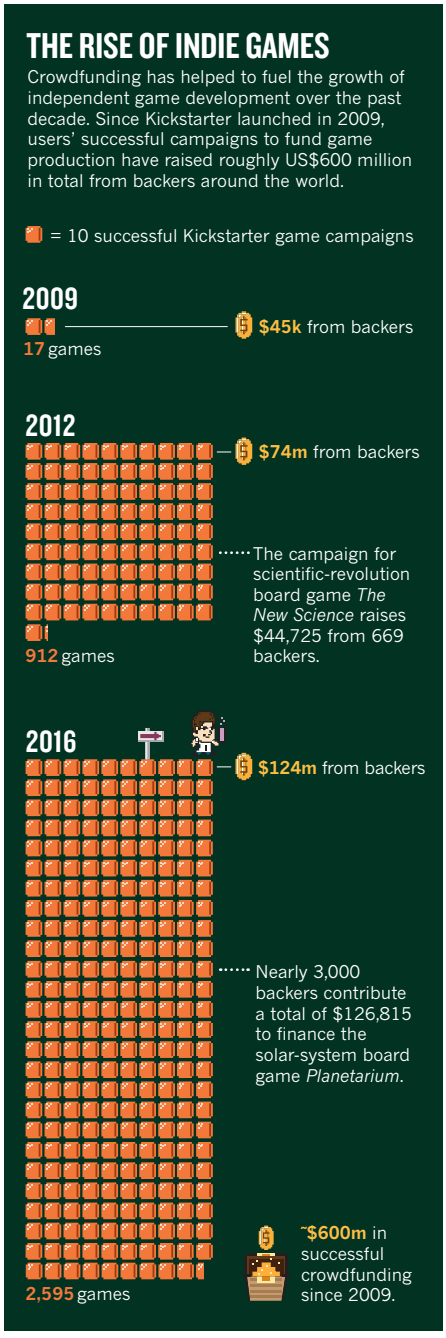
In a digital game, the core process should relate directly to the science, says science educator Andy Hall, founder of the game studio TestTubeGames in Cambridge, Massachusetts. In his special-relativity game *Velocity Raptor*, the player is a dinosaur travelling at near the speed of light, which its nemesis has slowed down. The dinosaur must dodge timed obstacles as space contracts and clocks tick differently. "You're really fundamentally interacting with space and time," he says.

Scientists often need to make trade-offs between accuracy and simplicity. Helena Shomar, a synthetic biologist at Delft University of Technology, the Netherlands, considered these compromises when her team was developing *Hero.Coli*, a digital game about an engineered microbe. Colleagues suggested the cell should divide. But she wanted players to focus on the main point — bacteria can gain functions by acquiring and combining DNA fragments.

Using familiar game rules and informal language can make the science more accessible. Ariel Marcy, an evolutionary biologist at the University of Queensland in Brisbane, Australia, and founder of the educational game company STEAM Galaxy Studios in North Ferrisburgh, Vermont, wanted to teach evolutionary trees. Because these trees are sets within sets, she based her board game *Go Extinct!* on the classic *Go Fish*, in which players collect sets of cards. In her game, players gather related animals to gain points; whoever has the most points wins. Building on an existing game made it easier for players to get started, Marcy says. In response to a middle-school student's suggestion, she also gave the animals nicknames, such as Warm Fuzzies for mammals and Toothy Grinners for archosaurs.

Beautiful artwork can attract players. Some researchers have found artists through social media or friends of friends. Costs can be $3,000–10,000 for a board game and tens of thousands for a digital game. But students may offer lower rates, and free art is available from OpenGameArt.org.

To print and deliver board games, scientists can seek company recommendations from other independent game developers. Lauretta worked with AdMagic in Netcong, New Jersey, and Whatz Games in Shanghai, China, for printing, and with Ship Naked in Londonderry, New Hampshire, for shipping. Prices vary depending on game complexity and factory site, but printing 2,500 copies of a board game with no custom components in the United States might cost around $20,000; printing only cards or manufacturing in China reduces expenses.



SOURCE: KICKSTARTER; CLAIRE WELSH/*NATURE*

PROFESSIONAL PARTNERS

For those who don't want to manage granular logistics, a partner company can help. In 2004, Klaus Eisenack, a resource economist at Humboldt University of Berlin, and Gerhard Petschel-Held, a German physicist, wanted to produce a climate-change board game. The pair approached companies at game fairs and signed a contract with Spieltrieb, a game-development firm in Niedermeilingen, Germany, which took care of tasks such as art, graphic design, printing, and management of sales and shipping. The scientists and sponsors, as well as partner individuals and organizations that placed pre-orders, helped to cover the initial production costs. Eisenack and Petschel-Held (who passed away in 2005) shared revenue with Spieltrieb. The game, called *KEEP COOL*, has sold several thousand copies, and Eisenack recouped his expenses (K. Eisenack *Simulat. Gaming* **44,** 328–348; 2012).

Digital-game designers often need support as well, particularly from engineers. Scientists can look for software-development companies at game festivals or find programmers through the International Game Developers Association in Mount Royal, New Jersey. Firms typically charge tens of thousands to hundreds of thousands of dollars, but some independent engineers may be willing to forego pay for a split of the profits.

Covering costs such as art and software development can be a challenge. In addition to crowdfunding, scientists have raised money through grants from their universities and scientific, environmental and charitable institutions. Microbiologist Carla Brown, founder of the science media company Game Dr. in Edinburgh, UK, won funding to produce *Bacteria Combat* from organizations such as the Society for Applied Microbiology, the Biochemical Society and the social entrepreneurship support foundation UnLtd, all in London.

Corporations also sometimes offer sponsorship. But scientists should ensure that arrangements are transparent and that firms do not influence the content in ways that make the researchers uncomfortable, Eisenack says. A fossil-fuel company approached his team about producing a version of *KEEP COOL* that would emphasize certain climate-change

solutions. But because he felt the changes would place undue weight on those areas, and the firm did not want to disclose sponsorship, Eisenack declined.

For a busy scientist, a board game may be more feasible than a digital game. Working with engineers can be slow because many rounds of prototyping and feedback are needed, and developers often juggle multiple projects. Apps are "immensely time-consuming", says Brown, who collaborated with the game-development firm Future Fossil Studios in Dundee, UK, to produce a digital version of *Bacteria Combat*. Working part-time on the project, the studio took about one year to program the single-player version and another six months for the multiplayer game.

But researchers can whip up digital games quickly and cheaply if they limit the scope. Atmospheric scientist Dargan Frierson and ecologist Josh Lawler at the University of Washington in Seattle recruited computer science, informatics and art students to make simple environmental games, some as volunteers and others for course credit. Most of the games are brief, single-player and 2D; they typically require one week to a few months of work to complete. "Communication of environmental science is urgent," Frierson says. "So we've got to get stuff out the door."

Scientists can market games through many channels. After Lauretta's team exhibited a prototype of *Xtronaut* at Toy Fair in New York City, *Good Housekeeping* magazine named it one of the best family board games of 2016. The US National Science Teachers Association reviewed *Go Extinct!* after Marcy submitted it to them. And browser-based games can be posted on the web portals Kongregate.com and Newgrounds.com.

Game development can be a distraction from research, but it can also bring scientists positive attention. Marcy won the Society for the Study of Evolution's 2016 Thomas Henry Huxley Award for outreach and education for *Go Extinct!* Posters for her game attract many visitors at research conferences, and she hopes that the connections she makes will later help her to secure a job.

Some scientists become full-time game developers, but it's tough to make a living in indie games. Hall lived off savings while starting his company, and established a sustainable business largely by creating games for clients such as museums. And researchers with coding skills may be able to get jobs at digital educational game companies, Stegman says.

But for scientists who pursue their passion on the side, making games is geek heaven. "Personally, it's very satisfying to have a box on the shelf that's a board game that I designed," Coil says. "I mean, that's just cool." ■

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TURNING POINT
Soft-skills sculptor

Maya Schuldiner, a yeast biologist at the Weizmann Institute of Science in Rehovot, Israel, won the 2017 European Molecular Biology Organization (EMBO) Gold Medal award for discovering the functions of proteins that no one had previously studied. She explains how finding her voice helped her to build a productive career, which has included launching and teaching a highly sought-after graduate-level course in soft skills.


THE WEIZMANN INSTITUTE OF SCIENCE

What have you struggled with most during your career?
It didn't occur to me as a student that one needs to learn more than how to work at the bench — with the possible exception of how to give an interesting talk. It surprised me when I started my lab and realized that most of the technical skills I knew were not that important in this role. The skills I needed were how to recruit the right people, how to pair the right project with the right person, how to write successful grants and how to motivate my students. I worried that if I asked older colleagues about these, they might think less of me.

How did you find the answers?
I was part of a cohort of 17 people when I started as a professor at the Weizmann Institute in 2008. We set up an early-career principal-investigator group to meet every two weeks and talk through one new skill — from how to write a letter of recommendation to how to fire someone. I started thinking that it would be nice to turn these into lessons for graduate students.

How was the class received?
The first year, I advertised the course on the Weizmann website. Around 120 people registered — half of the PhD students at Weizmann. I restricted it to 30 people to facilitate discussion. I'm now in my sixth year of teaching the course. I've increased the size to 50 students, but consistently get 120 registrants. It shows how hungry students are for this information. In Israel, because of compulsory military training, students are often older and have families with children. A lot want strategies for work–life balance.

What strategy did you use to launch your lab?
There were two things. I decided to work only with people I really like. I've created an environment where there's a strong feeling of friendship and camaraderie. Second, I took time to find my own scientific voice — my own special way of doing things. The first three years were scary because it took a bit more time than average to start publishing and be productive, but I wanted to find out what made me excited and could be uniquely mine.

What do you mean by 'find your own voice'?
It's my way of doing science — what questions I ask, how I ask them and what tools I use to answer them.

What worked well and what didn't?
I made a point of putting my students' and postdocs' needs ahead of mine, to be the kind of person they can trust to promote their well-being and agendas. Seeing that work made me happy and proud. I made some mistakes hiring people who weren't right for me or the lab. So I've learned to trust my intuition.

Do people call you 'Wonder Woman' for having three children and a career?
I hate it when people phrase it like that. It means that they think only a few people can do it. I don't think that's the case. The only reason I can do this is because of my husband, who is an associate professor also at Weizmann. We share every aspect of our lives. It's not as much about how I am, but how we are as a team.

Does the EMBO award validate your strategy?
It gives me a sense that the scientific path I've chosen is one that people find valuable, which is really moving for me. It comes also after a decade in the lab, when I want to enjoy what I've achieved and reflect on what went well and what didn't. If I want to continue doing interesting things, it's important to take a breather and really reflect on what to do in the next 10 years. ■

This interview has been edited for length and clarity.
INTERVIEW BY VIRGINIA GEWIN