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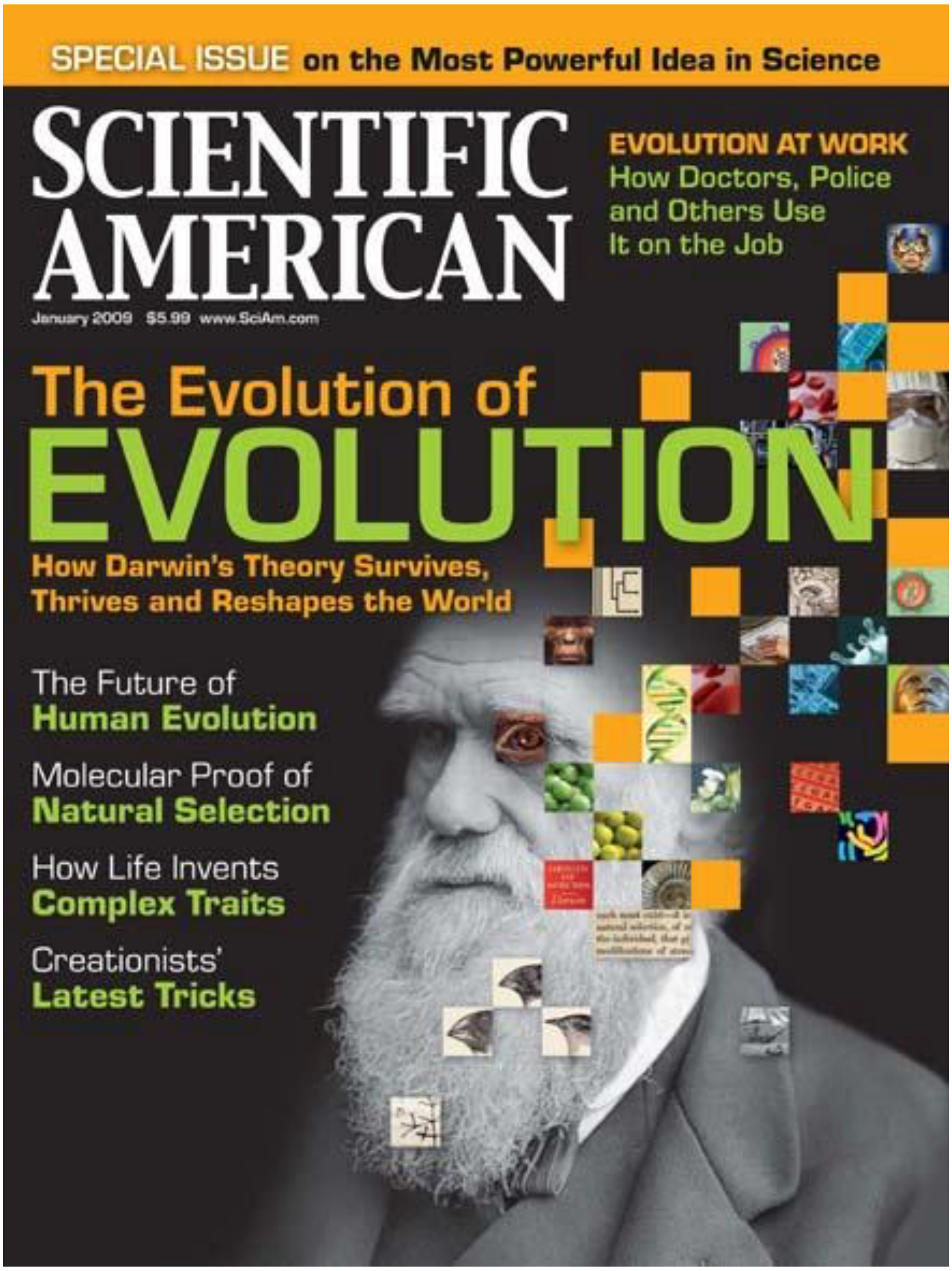

Steve: Welcome to *Science Talk*, the weekly podcast of *Scientific American*, for the seven days starting January 7th 2009. I'm Steve Mirsky. This week on the podcast, we'll talk about the January issue of *Scientific American* magazine, which is devoted to evolution and the evolution of evolutionary theory, because today's evolution is not your grandfather's or even your monkeys' uncle['s]. Editor in Chief John Rennie and I spoke at the magazine's offices.

Steve: What's the big deal with evolution John?

Rennie: Evolution, Steve!!! Evolution, it's only the most powerful idea in science, and 2009 is a very big year.

Steve: I figured that probably had something do with it. Why don't you tell everybody what the bigness is about [in] 2009.

Rennie: Well sure. It's actually kind of a doubleheader of the anniversaries related to evolution. First of all it marks the 200th anniversary of the birth of Charles Darwin. So Happy Birthday Chuck in February; and then it also marks the 150th anniversary, conveniently, of the publication of *On the Origin of Species* in which Darwin laid out his theory of evolution.

Steve: Which means for those of you doing the math at home, Darwin was 50 when *On the Origin of Species* came out.

Rennie: That's right.

Steve: And he had spent about 30 or about 20 years, basically sitting at home thinking about things and writing the book and we get into that in our opening article in the issue, for those of you not familiar with the Darwin story. You know, he was very leery about publishing and finally the pressure was on to publish because of Alfred Russell Wallace's discovery of basically the same principle of natural selection driving evolution.

Rennie: Exactly. Independently Wallace had come up with exactly the same sorts of insights and actually had come to Darwin and shown him some portions of his manuscript, and he was looking for feedback on that. And Darwin realized that the ideas that he had been ruminating over for 20 years since he had returned from the *Beagle*, that he was in danger of losing any claim to those; and so he, in rather a rush, wrote *On the Origin of Species*, which is actually kind of astonishing, because I don't think this is something you have commented on. *On the Origin of Species* is actually a beautifully written book. It's something of a masterpiece of exposition in laying out the entire argument. Of course, he had been thinking about it for 20 years, so probably it was all just right upstairs there in his head. But still it's really astonishing when you realize that's how it came out

Steve: And we really have Alfred Russell Wallace to thank for both compelling Darwin to publish as soon as he wound up publishing and for indirectly keeping *Origin of Species* as short as it is, because Darwin considered it to be an abstract of his larger thinking (laughs), and you know it's not a particularly short book. But anyway the lead article is more about the history, and then we get into some of the actual science, and we have the core ideas of modern evolutionary theory being laid out in the subsequent articles. There is your old buddy David Kingsley, who is Howard Hughes Medical Institute Investigator at Stanford, has an article in the issue about the sources of variation, which is really an interesting idea; where the variation comes from that natural selection works on.

Rennie: That's right. You know, I think a lot of people have a sort of na√Øve view that all of the sources of variation associated with evolution somehow come down to just different random point mutations. You know, the idea that [it']s all different little bits of radiation from ~~the~~ space pinging off of our DNA, randomly changing one nucleotide into another one. But that's not the case. In fact, although those kinds of point mutations are a very significant source of variation that natural selection acts on. In fact, what Dave Kingsley lays out is that there are, in fact, as biologists have discovered many different sources of variation that can come up. So we do have all kinds of point mutations, but also its possible to see entire whole pieces of DNA inserted into another creature's DNA and so that can be a source of very important variation. Genes can be duplicated and then those duplications can vary themselves; and then the various elements that regulate the activity of some of the protein-making portions of the DNA can themselves be under considerable amount [of] change. So in fact, there are many, many different types of variation that can show up inside our DNA, and all of those can be involved in natural selection. And all of those can, in many cases, because we have such a range of different types of variation that we can see the ways in which the kind of complex features will start to show up in organisms and how they can evolve sometimes remarkably efficiently.

Steve: There is a great picture in the Kingsley article of a little Whippet dog next to a dog that basically looks like, you'd really be hard-pressed just [to] spend eight seconds on it in a rodeo, and there is a single point mutation difference between those two animals.

Rennie: Right. There is a perfect example of how the tiniest conceivable genetic difference between one organism and another one can result in a huge change in the body—what we call a phenotypic change—where these certain kinds of whippets that have this particular mutation are hugely over-muscled. They have a gigantic amount of muscle mass and as you said so, it looks like some kind of bull rather than a little dog.

Steve: And by the way, the reason I said John's old friend, Dave Kingsley is, they went to college together about what, 60, 70 years ago?

Rennie: That's right. That's right. At the time DNA was very new.

Steve: Right. And you have H. Allen Orr who writes extensively on evolution talking about the continual recognition of the importance of natural selection.

Rennie: Right.

Steve: Natural selection has gone in and out of favor as the driving force in evolution, since Darwin first proposed it and now that we have the molecular tools to really test things at the single part of a gene level, it turns out natural selection really is that important.

Rennie: Right, you know, in a sense the important message that you could take away from H. Allen Orr's article about testing natural selection is that the world could work very, very differently. You know, as he points out, you could conceivably have, the biological world could have evolved ~~along the ways it~~ [in a way that] didn't involve natural selection in the ways we that talk about them. It might have played [a] much more minor role. But in fact, as biologists have gone in and studied the problem, we find in fact, lots of evidence that this kind of natural selection on mechanisms that are related to ones that Darwin sort of sketched out in a very broad way, that these in fact play a huge rule in evolution, much more of a role than we believed for a long time. Because, for example, for a long time there was an idea that many ~~sorts~~ of the changes that would show up in populations would be the result of neutral mutations; that in effect, one of those little events changing one nucleotide for another one, was essentially one was as good as the next one and there wasn't any particular ~~different~~ [difference] that natural selection would act one to favor one over the other. So it was thought that a lot of the differences between populations would be the result of really just sort of random chance, which is what he has referred to as genetic drift; but in fact when you go in an look at this, you find that natural selection has an extraordinary ability to act on a fantastically small levels of difference in fitness, and as a result that really does have a huge influence on shaping various populations.

Steve: For example, our ability of, some of us, to digest milk, the lactose in milk as adults, it's a very recent adaptation in evolutionary history.

Rennie: Well, right, because really until we started to develop agriculture, until we started to herd animals and collected milk as a good source of protein, mammals don't continue to breast-feed throughout their lives; so the young have the ability to digest breast-milk and then after they stop drinking it, they stop making that lactase enzyme that allows them to breakdown the lactose sugar in the milk. But we kept drinking milk: We raised cows and milk was a ready source of protein and other nutrients, and we would keep on drinking that throughout our lives. And so evolution started to act on the human populations and in populations that traditionally drank a lot of milk, we have this ability to keep making the lactose throughout our lives, or lactase throughout our lives.

Steve: Let's just explain a little bit mechanistically. I mean, its likely that the mutation that enabled adults to digest lactose cropped up now and again, you know, throughout the history of human evolution; but there was never any selection pressure to keep it around until we had agriculture and were starting to try to use milk as a nutritional source, as a food, as adults.

Rennie: Right.
Steve: At that point in human history, all of a sudden those individuals who happen to have this genetic mutation have a big advantage over their comrades who can't digest the lactose, and so the combination of the environment and that genetic influence makes that genetic construct get selected for and preserved in the population. And all of a sudden, you know, within a couple of thousand years, the majority of Europeans can digest lactose.

Rennie: Right. You know, that's a good point, because it's always important to remember, you know, people always have these sorts of arguments about nature versus nurture and are there genes for various traits; you know, discussions about genes for intelligence and so forth are always notorious about this sort of the thing. But the reality is, you can't really discuss a gene, the idea of a meaning of a gene outside of the environment in which it's going to be expressed. You can't really talk about the meaning that it has, what it will do, whether it has any sort of positive or negative value in that way. Ultimately, you know, we talk about genes as though they are building blocks for some sort of complicated traits, even a trait like, say, being able to drink milk. But of course, the reality is, the molecular biological reality is, that the gene is just a stretch of DNA that happens to make a protein that breaks down a sugar that is in milk. So only under a number of different circumstances in which people happen to have exposure to, they happen to have easy access to, a lot of milk that happens to contain a lot of lactose that they can't digest very easily unless they happen to still make a lot of the lactase enzyme that they all made as children. All of these circumstances come together to make something like that beneficial. Anything that breaks down that set of circumstances, it's just another little stretch of DNA that may not prove its worth and as you said, it vanishes back in as random noise again.

Steve: Right. Without the pressure to keep it, it disappears.

Rennie: Yeah.

Steve: There's a fascinating thing in your most recent comments on what you think about; and that is that, you know, probably everybody listening took an introductory biology class at some point, and you saw Mendel's pea plant genetics with the smooth and the round peas and the tall or short stalks. And in the issue it discusses briefly at one point how the understanding at the genetic level is now complete enough where we know exactly what those mutations were, what changes in the DNA code occurred that Mendel was studying. He didn't, of course, know he was studying it. He was studying the phenotypes; he was studying the macro information that was available to him with his hand[s] and his eyes. That was the best that he could do, and he did an amazing job with that, but it's just fascinating that we now know exactly to the letter of DNA code what was going on in the plants that he was working with that made the smooth pea wrinkle; it's just an amazing thing that information now exists all as a whole.

Rennie: Right. Also, in a way, it's easy to lose track of the effect [fact] that when Darwin was first theorizing and when Mendel was working on [this], the underpinning[s] of heredity were a complete mystery. Nobody knew how it was [that] ~~the~~ traits ~~that~~ [were] passed on from a parent to a child. There were lots of different theories about it, but nobody knew what the mechanism of it was; which is why, in fact, Darwin actually he subscribed to, at least [he was] open to the possibility of the idea that what he was calling, sort of, little gemmules and some sort of element that might have transmitted hereditary information from parents onto offspring, that you might have actually had some kind of Lamarckian mechanism; that the experience of the parent organism might have changed what its hereditary contribution would be. We now know that wasn't true or so it is not simplistically true, but you know, they were very open to this. This is the amazing thing. The whole idea of all these ideas about how it is that you could have extraordinary things evolve in the biological realm through this mechanism of natural selection acting on variations in the population all was done without any idea of DNA, without any idea of a sophisticated idea of [how] inheritance worked at all.

Steve: It really is amazing.

Rennie: Well, you know, in a way it also speaks to, I talked about the idea of evolution as being the most powerful idea in science before, and it's because [of] that insight ~~of~~ that systems will evolve if[at] any time in which you have some sort mechanism of selection that is acting on some sort of underlying set of variation. So you don't have to have, it doesn't have to be a biological system. The ideas of evolution have turned out to be very useful to chemists. They have turned to be useful to physicists and astrophysicists. It's the idea that, oh, if you have something that's tending to ~~scream~~ [screen] out and select for certain kinds, that you will then have the very orderly progressive form of evolution without it being directed by anything. That's an extraordinary insight.

Steve: Some of the other articles in the issue include a look at human anatomy by Neil Shubin, author of the recent best seller, *Your Inner Fish: Journey into the 3.5-Billion-Year History of the Human Body;* David Mindell's take on evolution in the everyday world, which looks at how healthcare, law enforcement and other disciplines use evolutionary theory; David Buller's piece on the fallacies of pop evolutionary psychology and "The Latest Face of Creationism" about the ongoing threat post to science education by anti-evolution political forces. That analysis is from Glenn Branch and Eugenie Scott of the National Center for Science Education. The entire issue is available, much of it free, at http://www.SciAm.com/jan2009.

I was reading an evolution essay last week by Julian Huxley originally written in 1942 and updated in 1963 called "Evolution: The Modern Synthesis". I just want to share a short passage. After a discussion of the structural characteristics of DNA, Huxley writes, "The various properties of DNA, which I have mentioned, to make evolution inevitable, the existence of an elaborate self-reproducing code of genetic information ensures continuity and specificity; the intrinsic capacity for mutation provides variability; the capacity for self-reproduction ensures potentially geometric increase and therefore a struggle for existence; the existence of genetic variability ensures differential survival of variants and therefore natural selection and this results in evolutionary transformation."

That's ~~said~~ [it] in a nutshell, kids.

Steve: Now it's time to play TOTALL....... Y BOGUS. Here are four science stories; only three are true. See if you know which story is TOTALL....... Y BOGUS.

Story number 1: Something Darwin missed during his trip to the Galapagos—a newly identified pink Iguana species.

Story number 2: Public health researchers are now concerned over what they have dubbed third-hand smoke.

Story number 3: The Milky Way galaxy is spinning more slowly and is somewhat smaller than was previously thought.

And story number 4: President Bush this week became a leading protector of the world's ocean environment.

Time is up.
Story number 1 is true. The pink Iguana species originated in the Galapagos more than five million years ago and diverged from the islands' other Iguana populations when the archipelago was still forming. That's according to genetic analysis published in the *Proceedings of the National Academy of Sciences*.
Story number 2 is true. So called third-hand smoke is a hazard according to public health researchers. Third-hand smoke is all the nasty stuff in cigarette's smoke that winds up embedded in carpets, drapes, clothing, hair and anything else that will absorb it. Infants and children are particularly at risk of exposure to the carcinogens according to a report in the journal *Pediatrics*.
And story number 4 is true. This week President Bush protected some 335,000 square miles of U.S. territorial waters. Added to waters off of Hawaii that were protected in 2006, it makes Bush responsible for the largest areas of ocean protections ever so designated. For more check out David Biello's blog item posted on our Web site on January 6th.
All of which means that story number 3, about the Milky Way Galaxy being slower and smaller is TOTALL....... Y BOGUS. Because what is true is that we are actually bigger and faster. Astronomers announced this week that in our position in the Milky Way, we are moving at 600,000 miles per hour, give or take a couple, 100,000 thousand miles faster than previous estimates, and the galaxy therefore must be half again as massive as we thought to allow that speed without us hurdling out of orbit. That's according to research presented at the meeting of the American Astronomical Society this week. For more check, out the January 5th episode of the daily *SciAm* podcast, *60-Second Science*.
(music)
Well that's it for this edition of *Scientific American*'s *Science Talk*. Check out www.SciAm.com for the latest science news, our very timely In-Depth Report on the science of weight loss and our feature on ten lessons medicine can learn from bears, which includes lots of pictures of baby bears that will make you say, bujubujubu lubidiloo bobo.... For *Science Talk*, I'm Steve Mirsky. Thanks for clicking on us.

***Science Talk* is a weekly podcast, subscribe here: RSS | iTunes**
Scientific American Editor in Chief John Rennie discusses the special January issue of the magazine, which focuses on evolution--2009 being the 200th anniversary of the birth of Darwin and the 150th anniversary of the publication of *Origin of Species*. Subjects in the issue include the importance of natural selection, the sources of genetic variability, human evolution's past and future, pop evolutionary psychology, everyday applications of evolutionary theory, the science of the game Spore, and the ongoing threat to science education posed by creationist activists. Plus, we'll test your knowledge about some recent science in the news. Web sites related to this episode include www.SciAm.com/jan2009
Close Transcript

ABOUT THE AUTHOR(S)

Steve Mirsky
Steve Mirsky has been writing the Anti Gravity column since a typical tectonic plate was about 35 inches from its current location. He also hosts the *Scientific American* podcast Science Talk.