Corals can pass mutations acquired during their lifetimes to offspring

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The Elkhorn coral, Acropora palmata, grows into large stands via polyp budding and fragmentation so that many colonies belong to the same clone or genet. During growth, mutations can accumulate in its cells and new research shows that the Ekhorn coral is able to pass these mutations onto to their sexual offspring. This is unlike most animals that prevent such a transfer from the body to reproductive cells. Credit: Iliana Baums

In a discovery that challenges over a century of evolutionary conventional wisdom, corals have been shown to pass somatic mutations—changes to the DNA sequence that occur in non-reproductive cells—to their offspring. The finding, by an international team of scientists led by Penn State biologists, demonstrates a potential new route for the generation of genetic diversity, which is the raw material for evolutionary adaptation, and could be vital for allowing endangered corals to adapt to rapidly changing environmental conditions.

"For a trait, such as growth rate, to evolve, the genetic basis of that trait must be passed from generation to generation," said Iliana Baums, professor of biology at Penn State and leader of the research team.

"For most animals, a new genetic mutation can only contribute to evolutionary change if it occurs in a germline or reproductive cell, for example in an egg or sperm cell. Mutations that occur in the rest of the body, in the somatic cells, were thought to be evolutionarily irrelevant because they do not get passed on to offspring. However, corals appear to have a way around this barrier that seems to allow them to break this evolutionary rule."

Since the time of Darwin, our understanding of evolution has become ever more detailed. We now know that an organism's traits are heavily determined by the sequence of their DNA. Individuals in a population vary in their DNA sequence, and this genetic variation can lead to the variation in traits, such as body size, that could give an individual a reproductive advantage.

Only rarely does a new genetic mutation occur that gives an individual such a reproductive advantage and evolution can only proceed further if—and this is the key—the individual can pass the change to its offspring.

"In most animals, reproductive cells are segregated from body cells early in development," said Kate Vasquez Kuntz, a graduate student at Penn State and the co-lead author of the study.

"So only genetic mutations that occur in the reproductive cells have the potential to contribute to the evolution of the species. This slow process of waiting for rare mutations in a particular set of cells can be particularly problematic given the rapid nature of climate change. However, for some organisms, like corals, the segregation of reproductive cells from all other cells may occur later in development or may never occur at all, allowing a path for genetic mutations to travel from a parent's body to its offspring. This would increase genetic variation and potentially even serve as a 'pre-screening' system for advantageous mutations."

Corals can reproduce both asexually (through budding and colony fragmentation) and sexually, by producing egg and sperm cells. For the Elkhorn corals studied here, which broadcast their egg and sperm cells into the water in spawning events, eggs from one coral colony are usually fertilized by sperm from a neighboring colony.

However, the research team found that some Elkhorn coral eggs developed into viable offspring without a second coral being involved, a kind of single-parent sexual reproduction.

"This single-parent reproduction allowed us to more easily search for potential somatic mutations from the parent coral and track them into the offspring by simplifying the total number of genetic possibilities that could occur in the offspring," said Sheila Kitchen, co-lead author of the study, a postdoctoral researcher at Penn State and the California Institute of Technology co-lead author of the study.

The research team genotyped samples—using a high-resolution molecular tool called a microarray to investigate DNA differences between the samples—from ten different locations on a large Elkhorn coral colony that had produced single-parent offspring, and samples from five neighboring colonies at nearly 20,000 genetic locations.

The results showed that all six of the separate coral colonies belonged to the same original coral genotype (known as a "genet"), meaning essentially that they were clones derived from a single original colony through asexual reproduction and colony fragmentation. Thus, any genetic variation found in these corals would have been the result of somatic mutation. The team found a total of 268 somatic mutations in the samples, with each coral sample harboring between 2 and 149 somatic mutations.

The team then looked at the single-parent offspring from the parent Elkhorn coral colony and found that 50% of the somatic mutations had been inherited. The exact mechanism of how the somatic mutations make their way into germline cells in the corals is still unknown, but the researchers suspect that the segregation between body and germline cells in corals may be incomplete and some body cells may retain the capacity to form germ cells, allowing somatic mutations to make their way into offspring. They also found evidence for the inheritance of somatic mutations in some offspring from the mating of two separate coral parents but will need additional studies to confirm this.

"Because corals grow as colonies of genetically-identical polyps, somatic mutations that arise in one coral polyp can be exposed to the environment and screened for their utility without necessarily affecting the entire colony," said Baums.

"Therefore, cells with potentially harmful mutations may die off and cells with potentially advantages mutations could thrive and spread as the coral colony continues to grow. If these mutations can then be passed on to offspring—as we have now demonstrated—it means that corals have an additional tool that might be able to speed up their adaptation to climate change."

A paper describing the research appears in the journal *Science Advances*.

More information: Iliana Baums et al, Inheritance of somatic mutations by animal offspring, *Science Advances* (2022). science.org/doi/10.1126/sciadv.abn0707

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