CORALS - Curated Transcript of BBC In Our Time podcast
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In Our Time is hosted by Melvyn Bragg. Melvyn's guests on this podcast are:

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Nicola Foster
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And

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Transcript:

[Melvyn Bragg] Hello. Whenever shipwrecked sailors find sanctuary on a desert island under a coconut palm, they can thank coral. These tiny, undersea creatures, once dead, leave behind stony skeletons. And more corals grow on those until they form a mountain, its peak above the water; the sailor on that peak. Meanwhile, the submerged corals, sometimes called the rainforests of the oceans, teem with life, or in the case of many, did team until killed by rising water, acidity and temperatures and the great storms that come with climate change. With me to discuss coral are Nicola Foster, Lecturer in Marine Biology at the University of Plymouth, Gareth Williams, Associate Professor in Marine Biology at Bangor University School of Ocean Sciences and Steve Jones, Senior Research Fellow in Genetics at University College London.

[Melvyn Bragg] Steve Jones, what did Charles Darwin notice from the Beagle when looking at coral islands?

[Steve Jones] I think it was a very important moment for him because nobody had before had really understood how a coral island could spring out from a deep ocean, because corals need the light to grow. So how could they grow towards the surface when it obviously hits pitch black a long way down? And Darwin, as he was on the Beagle, he went past or he visited a coral atoll called Cocos Keeling, and he saw something which really formed his whole view of geology. And of course, he was as much a geologist as he was a biologist, and also led to the idea of evolution because he realized that what was happening was a pattern of slow change over immense periods of time, which led to the appearance of, in this case, new islands out in the deep ocean. And he got it right first time, really.

[Melvyn Bragg] How did you notice that? So how did he leap to that? You could say it was a massive stroke of genius? But how did he arrive at it?

[2:06]
[Steve Jones] Well, he he would he went to Cocos Keeling and he knew full well that corals were a living creature, and yet if you went too deep, they couldn't grow. So he postulated that actually what was happening was that below the coral reef itself there was a foundation, a sea mount, as they're sometimes called, which is a gigantic basaltic thing of hot rock, comes bubbling out of the Earth's surface and then because it's heavy, it sinks back in again. Okay? Edinburgh Castle is on one of them and Edinburgh Castle is slowly sinking into the Forth. I don't think we'll see that in our lifetimes, but this is what the sea mounts do. So he realized what was happening was the sea mount will come bubbling up - Hawaii is a sea mount, for example - and then as it sank the reefs would be able to keep growing and keep up to the surface. So we realized that a very slow process of change, by very unimpressive animals in some ways, could have a massive geological effect. And that led him directly to the notion that in the same way, a very slow process of changing biology could lead to the emergence of new species, humans included, and hence his observation of this island was really the germ that sparked off the idea of evolution by natural selection.

[Melvyn Bragg] And it was his first book.

[Steve Jones] It was his first book, in fact, to be completely precise, his first book was a very boring book ... called "The Zoology of the Beagle". But that was really more of an enormous journal than a book. But coral, like most of Darwin's writings, is a surprisingly easy and good read. You get a feel for the excitement of seeing this stuff and understanding it for the first time.

[Melvyn Bragg] How did these tiny creatures make such enormous structures? We're told that the Great Australian Barrier Reef can be seen from space and so on. How come?

[Steve Jones] Well, they do it in the same way that life does it by staying alive and sucking salts out of the water and fixing carbon. And the carbon which comes from the air, carbon dioxide in the air, they can actually use that because they have within their bodies, these corals, many of these corals, ... little green algae called zooxantheli which are in their bodies and can pick up sunlight and use that to power the metabolism of the carbon animal, the polyp, as it's known. Symbiosis is the word that people use because the little green sections within the coral animal were initially independent living creatures which came in and found a home there and they get nutrition from the coral animal and they soak up energy from sunlight and the coral animal uses that to drive its own machinery.

[Melvyn Bragg] How did it come about that what you keep calling a coral animal was for so long thought of as a rock?

[Steve Jones] Well, nobody could really imagine that animals could make rocks. I mean, it does seem a bit counterintuitive, but they can. Darwin's great insight was not just that that was true, but actually that a constant slow process could generate huge things like the Great Barrier Reef. Okay? Nobody had an idea what they were at the Barrier Reef was all about. I mean, Captain Cook was wrecked on the Barrier Reef, but the idea that he was wrecked on something which [was] made by a living organism was completely alien to everybody.

[Melvyn Bragg] Nicola Foster, can you tell us what's an individual coral? Can you describe that anatomy?

[5:35]
[Nicola Foster] Yes, so Steve has very nicely described how the corals form these large reef structures. But these corals are actually colonies, so they're formed of individual polyps which are just a few millimeters in size and the corals are related to jellyfish and sea anenomies and so the best way to describe a coral polyp is that it is an upside down jellyfish, basically. And it's this hollow sack, and inside the sack, it has a kind of stomach with digestive filaments, and at the top of this sack, there is a ring of six tentacles around a central mouth. That mouth is the only entrance and exit into the polyp. So food and waste go in and out of this same opening. And this hollow sack actually sits within a limestone cup that the coral makes itself. This is known as the calyx, and it actually provides protection for the coral polyp. So it can actually withdraw itself into this limestone cup to protect itself from predators and from the elements. So at the top of the polyp, it has these tentacles and it uses these to catch food at night. So, Steve has very nicely described the way that the corals also use algae within their cells to generate food, but they're also able to get a small amount of energy from catching microscopic organisms. And they use these tentacles at night, and they have small stinging cells within them called nematocysts, and they use these to sting microscopic organisms, and then they sweep these organisms, or these animals, into their mouth using their tentacles. So these individual coral polyps are very small. They're only a few millimeters across, but they can actually form these really large colonies that actually work together as one organism. And they do this by connecting each of these polyps to the neighboring polyps by a small piece of tissue, and the limestone cup that they sit in also cements together. And when hundreds of these coral polyps cement together, they form a large colony and these large colonies grow next to and on top of one another, and this is how they form these large coral reefs.

[Melvyn Bragg] Nicola, and for those who haven't had the opportunity to look up close, what's it like to dive among these coral reefs?

[7:47]
[Nicola Foster] It's mesmerizing. I think the best way to describe it is like you're diving in a huge aquarium and it's just bursting with color and with life. And I think the first thing you notice are actually the colors - all the colors you can imagine, all the colors from the rainbow are just right there in front of you. And you see this large three dimensional structure. It stands up from the seabed, which is the coral reef, which is built from these stony corals. And they're just multitudes of shapes and sizes. So you have branchy corals that look like trees with no leaves. You have table corals where the branches fuse together and they form sort-of table-like structures. And then you have what we call foliose corals that actually look like lettuces, heads of lettuces with leaves. And then you have corals that look like mushrooms and large boulder-shaped corals. So there's this huge diversity of shapes and sizes. And in amongst these stony corals, you have soft corals and we have small ones that look like heads of cauliflower or broccoli and again they're such amazing colors, so pinks and purples and yellows and greens. And then we have sea fans that form these large treelike structures that are, again, another type of soft coral. There are sponges amongst all of these of different shapes and sizes and it's just teeming with life. So there are thousands of species of fish and invertebrates all around and then if you get closer to the reef, as you get closer and look in amongst the corals, there are hundreds of different species. So you have these small Christmas-tree worms that live ... inside the coral limestone structure and they pop out - they look like miniature Christmas trees. On the corals there are starfish and sea urchins. It's just teeming with life, and I think one thing that you don't expect is the sound. So you would expect diving on a reef to be actually quite quiet but it's actually really loud. So there's a whole orchestra of bubbling and crackling and clicking and snapping and popping and this is noises made from the animals that are living there. So we've got snapping shrimp and fish feeding and it makes all these wonderful noises. And I think the best way to describe the noise is very similar to the popping candy you would have as a child that you would put on your tongue and listen to and that's a very similar sound to what you hear when you're on the reef.

[Melvyn Bragg] Gareth, you're a deep sea diver. Have you anything to add to that vivid description of Nichola's?

[Gareth Williams] No, I mean Nicola has [provided] a great description for anybody that hasn't seen a coral reef. I think if you've never been privileged enough to visit a coral reef firsthand and you've seen coral reefs through nature documentaries, for example on the television, you probably would expect the opposite. You're expecting, because of the overcues that are often played over the visions of the reef, this ... type [of] music that often goes along with nature documentaries, you're expecting that kind of tranquil setting that Nicola is talking about. But she's absolutely right, I mean, there's all these noises going off around you and the noises are those diverse array of organisms that Nicola mentioned, eating and fighting and mating, all the things that organisms do and they're doing all those things. And because there are thousands of organisms, there are thousands of sounds that create this cacophony as Nicola was mentioning - it's mesmerizing.

[Melvyn Bragg] You visited and dived in different coral reefs around deserted islands all over the world. What are the major differences?

[11:10]
[Gareth Williams] Reefs look really different from each other. I often say a reef is not a reef is not a reef. They all have their own story to tell. They have different species and different abundances and, as a consequence, no two islands look the same. And that's with the human kind of impacts removed. There's all that variety, and that natural variety is caused by gradients and things like wave energy and food availability. Like Steve mentioned, with more waves, we see less coral, perhaps because the waves can damage corals and break them up. With more food, supporting higher trophic levels like fish,... you see more fish and more fish biomass... And these natural bounds shape the system that you see. And human impacts are then superimposed over the top of those natural bounds. And the challenge then is to discern what variation is caused by these natural gradients and what is caused by us as humans.

[Melvyn Bragg] Is there such a thing as a pristine coral reef anymore, Gareth?

[12:03]
[Gareth Williams] I'm afraid to say I don't think there's a pristine ecosystem left on our planet, sadly. Human impacts are so ubiquitous on planet Earth that I don't think you can call any ecosystem truly pristine anymore. I do think, though, there are some near-pristine examples of coral reefs. Coral reefs are fascinating in the way that they provide examples of some of the most degraded ecosystems on our planet, but at the same time provide examples of some of the most near pristine. And here I'm really talking about, in particular, very remote systems that are many hundreds of miles away from the nearest human settlements that lack those local direct human impacts like fishing and pollution. And there are some really characteristic things that stand out when you visit these remote reefs. In my mind, there are three things that really stand them apart from reefs that are heavily degraded. First of all, there's an enormous amount of fish, in particular, predatory fishes, big sharks, jacks, groupers, all those kinds of things. The second thing that really stands out is when you look at the reef floor, everything you're staring at on the reef floor, just about, is helping to build the coral reef. It's laying down that calcium carbonate. It's helping to grow the reef and keep pace with sea level change. And the third most striking thing for me when I visit these remote systems is the clarity of the water. You can see as far as your eyes will let you, really. And it's because, in degraded systems, we have a lot of bacteria and viruses in the water that create a lot of cloudiness. When you visit these remote systems, that's obviously not there, and, in fact, some of the systems we visited, our group has visited an island, one atoll, Millennium Atoll in the south central Pacific, that has a central lagoon that has so many giant clams that are filtering the water, it's almost impossible to detect any microbes or viruses. It's sort of like purified seawater; it's like diving in bottled seawater; it's absolutely incredible.

[Melvyn Bragg] Steve, what's the relationship between the coral polyps and the algae inside them?

[13:53]
[Steve Jones] Well, the coral polyp is a classic example of something we call "symbiosis" - living together. Okay? And it was in Darwin's day, some time later, when this became clear. This was always seen as some kind of great, beautiful, charming friendship between two very different creatures, both of whom helped the other one to stay alive. Okay? And the Russian politician Kropotkin actually mentions corals as an

example of a kind of semi-socialist system. There is a lot of tension between the little green structures inside the coral and the coral animal itself. Each one is interested only in its own future. It's not interested in the slightest in the other one. It wants to extract as much as possible and give as little as possible. And you can see that, particularly when you have events where maybe there's an unduly sunny summer, shall we say, or there's been a big storm on a reef. What happens is that the little coral symbionts, the little green things, they just leave. They think, "Oh, to hell with this!" Okay? They just go off, and they live independently in the ocean until things get better back on the reef, and then they'll come back in. And that causes what we call coral bleaching. And coral bleaching has always been seen as some kind of terrible sickness, and it's all due to human effects. Now, some of it certainly is - you can't deny that. But there's a tension - there's a dynamism - in this relationship. The Great Barrier Reef, for example, has bleached several times over the last five years, but it still survives, and in time, it may well regenerate itself. Although I have to say there's been so much pressure on that particular reef now that it's hard to know whether it ever come back to its pristine state. There is a constant battle going on between the reef and the outside world and between the elements of the reef itself. And in some ways, that's why they've become so fragile, because anything which is an uneasy truce can easily break out into war. And that's what we've been doing. We've disturbed the truce all over the place, and so war has broken out, and the reefs are paying the price.

[Melvyn Bragg] Nicola, ... is there any way you can develop that? And not only about coral bleaching, but how great is the threat to reefs?

[16:20]
[Nicola Foster] Coral bleaching is a huge threat to reefs, and it's caused by a range of stressful conditions. So when the corals get stressed, they lose their algae. And when the algae are expelled from their coral hosts, this leaves the coral without their food source, basically. So they get the majority of their food source from the algae. And so they're literally starving to death, and it makes them more vulnerable to diseases and to degradation. And as Steve mentioned, the corals, they can recover if the stressful conditions are alleviated. It's a little bit like the coral is holding its breath. If the stressful conditions continue too long, so weeks or months, then the corals will eventually die, and they will starve to death. If the conditions return to normal, they can recover. They can take up algae again from the water. Or if the bleaching was quite mild, they may still have a small population of algae within their cells, which they can then recover. But ... if they've experienced bleaching, they will have this reduced growth, reduced reproductive capacities ... (they won't be able to reproduce at the same level they could previously) and they'll be susceptible to disease. And so this bleaching is caused by a range of stressful conditions, which could be land or marine based pollution - so fertilizer runoff or ship discharges, changes in salinity and exposure to air or changes in water chemistry. But these stressors that tend to cause bleaching are quite localized, so just on tens of hundreds of meters. And the bleaching that is the real threat to corals is that which is happening on a much wider scale. So we call it's termed mass coral bleaching, and this typically covers hundreds of kilometers. And the main cause of this mass coral bleaching is an increase in ambient sea water temperature. So corals live very close to their maximum temperature, and just a one degree rise above this maximum temperature for a minimum of four weeks can result in widespread bleaching. So they live in this very delicate balance, and when reefs bleach on this scale, it's over hundreds of kilometers, we're talking about entire reefs,

then there is a real risk that these reefs will become degraded and that if it's extended over an extended period, they won't be able to recover, and that's when we start to see these reefs degrading.

[Melvyn Bragg] Thank-you. Gareth, I've read though, from what you and others have written, that bleaching, it looks terrible, and then they regather their strengths and come back again. How true is that at the moment?

[Gareth Williams] Absolutely. There's certainly evidence that reefs can recover. I mean, over their geological history, they've been disturbed by storms, naturally, well before humans were around. And so there's been this natural development of reefs to regrow in response to the disturbance, in the same way that, you know, Steve was talking about that that succession. Reefs are always, you know, going through that ecological succession following disturbance. The challenge, I think, now is that these disturbance events, such as mass coral bleaching that Nicola was mentioning, are just becoming so frequent that that time window for recovery in between those disturbance events is closing and becoming, you know, less and less. Steve mentioned about the number of bleaching events on the Great Barrier Reef just in the last five years. And some work by our group using global climate change models [shows] that potentially, by the end of this century, all coral reefs on our planet will be exposed to bleaching induced temperature stress every year, which means there'll be no time for recovery in between these disturbance events, you know. And so it's that closing gap that worries me.

[Steve Jones] Yeah. I mean, the interesting thing is, you know, we're so used to seeing coral reefs on television, as Gareth said, that you tend to assume that they're everywhere. Okay? But in fact, the total area of coral reefs of the type that we associate with Hans and Lotte Hass, and all those people in David Attenborough, is only about twice the area of the British Isles. So actually it's a ...pretty rare habitat and they are sometimes called the rainforests of the sea. But the difference is that the area of the rainforest is hundreds of times the area of the British Isles. So these things really are fragile and I think we tend to disregard that simply because you can't see them most of the time, you tend to forget that they are really being pushed over the edge.

[Melvyn Bragg] Do you think, Steve, that if they disappeared, that would have a deleterious effect on us humans?

[20:37]
[Steve Jones] I think on some populations of humans it would, which, for example, if you take when Captain Cook crossed the Pacific and he discovered Hawaii, he was astonished by the number of people there. There were more people on Hawaii in Captain Cook's day than there are now, and I've been to Hawaii and it's a big, busy, rather spoiled part of the world. And that's ... because these people effectively lived off the sea and they lived off, most of the time, the reefs. And they had a very hierarchical structure. Queen Victoria was all in favor of it because, of course, they had a monarch and monarch was in charge and that was the way that things ought to be. But the joy of the hierarchical structure was that there were very strict rules about who on Hawaii and elsewhere, was allowed to go on to the reef. And you had to be an aristocrat, in some senses, to go onto the reef. And to go on to some of the most productive parts of the reef, you almost had to be the royalty of the area. And they were actually very good

conservationists because, before the appearance of Cook and people basically pillaged the reef, there were areas that were set aside not to be used for fishing, not to be trampled on from year to year. So they maintained a huge population. And of course that huge population was devastated when when the westerners arrived, largely because they brought disease and the disease roared through the coral islands, really depopulating them. So the coral islands that we see today are an absolute remnant of what would have been there before Europeans got into the Pacific.

[22:13]
[Gareth Williams] I think actually the loss of coral reefs will affect all people on our planet and I think perhaps [different] people in different ways. For example, in the Pacific island nations, about 90% of people live within 5 km of the coastline, so they live within 5 km often of a coral reef. And many of these people are obtaining all of their protein, their micronutrients from the reef, things like zinc and calcium and iron, things that stave off and prevent childhood diseases, so the food for these people from coming from reefs is extremely important. With the loss of reefs and the loss of the fisheries associated with these reefs, many of these people will starve to death. But I also think that people living in inner-city Manchester or London can be affected by the loss of coral reefs as well, I do, and I've been asked, "How can that possibly be?" And it's because ...everyone should care about the loss of coral reefs. If you care about biodiversity, then you're going to be impacted if coral reefs go away because we're going to see a loss of biodiversity. If you care about medicines, you're going to be impacted. We see many medicines discovered on coral reefs, anticancerous properties, for example. ...Maybe you think you don't care about coral reefs and are disconnected from them completely, but if you care about things like immigration patterns, you care about coral reefs. Because with the loss of these coral reef islands, hundreds of thousands, if not millions of people, will have to be re-homed, many of which are UK overseas territories that have tropical coral reefs around them. So I actually think that with the loss of coral reefs, everybody on our planet will be in some way affected.

[Melvyn Bragg] Nicola, Nicola Foster, can you take us into deeper waters, as it were? What are the corals like at great depths where there's much less sunlight?

[23:46]
[Nicola Foster] So as you move deeper beyond the shallow reefs, you enter what's known as the mesophotic zone. And this zone sits between the brightly lit shallow waters and the deepest depths of the ocean. And mesophotic actually translates to middle light. And so it's between about 30 to 150 meters in depth, and this is the furthest depths that the sunlight reaches into the oceans. And in the tropical water, the tropical waters tend to be much clearer, and so the communities that rely on sunlight can actually live at these fairly deep mesophotic depths. And we've had stony corals recorded at around 100 to 170 meters. So the same coral species that we're finding on these shallow reefs are found on these deeper depths. But as you move deeper through the mesophotic zone, the coral communities change. And so while sunlight is still present, it's in much lower concentration than it is at the surface. And so not all of the species can survive at these depths. And so you get a shift in the communities that you have there and you also get a shift in the size and shape of the corals and other organisms that live there. So for the stony corals at these deeper depths, they tend to have a platelike growth form. And so by doing this, they're forming plates out of their

limestone structure and they're doing this to maximize their surface area and to capture as much light as they can. And this is for the algal symbionts that Steve previously mentioned that live within their tissues. And so between about 30 to 70 meters. The communities that you see are often an extension of shallow water reefs. So it's quite similar species with just maybe a few less stony coral species than you would have at the shallow reefs. But it's just as vibrant, it's just as colorful. We still have all of the sponges, the soft corals, and these beautiful large sea fans, and it's also teeming with fish and other invertebrates at these depths. But as you move deeper, beyond 90 meters, we have less stony corals because of the decrease in sunlight. And what happens is this leaves space for other species to occupy. And so from about 90 to 120-130 meters, it's the soft corals and the black corals that really dominate these communities. So the soft corals I talked about earlier, they can be these small colonies or these huge treelike structures. But the black corals, they're slightly different. So they're not black, as the name would suggest, but they're these large bushy formations, often in vibrant colors of yellow and red and green, and they have a black skeleton. So this depth band has the most stunning communities with these huge sea fans and the large bushy, black corals, which stand about a meter high from the seabed, and you also have an abundance of other organisms. And so these deeper reefs are really important communities in their own right. And it's estimated that they actually may cover the same surface area as the shallow water reefs, and they may actually provide some of those same services that Gareth was talking about, so they may actually be a source of food, so we get a large number of fish species, commercially important fish species, down at these depths as well. They might be an important source of medicines, as Gareth talked about, and they also provide that barrier, so that protection to islands as well. And so these are really, really important reefs. So if you go beyond this depth, so if you go below 200 meters, you're officially entering the deep sea, and so you don't have the sunlight anymore. And what you have then is... you have these deep cold-water corals below 200 meters, and they don't have that relationship with algae, but you still have these really important coral structures at these depths as well.

[Melvyn Bragg] Thank you. Gareth, what's the relationship between corals and prevailing waves and currents around the globe?

[Gareth Williams] Waves are, [after] corals, my second favorite thing. And of course, the two things interact and waves shape coral reefs. Quite literally, corals change [and] shape depending on the wave energy, as Nicola was alluding to. So if there's high wave energy, you'll often see very low-lying corals, encrusting corals, that reduce that drag, so they're not as vulnerable to breakage by things like waves. But corals, of course, can affect waves in turn, and soak up that wave energy. As the waves break over the corals, that dissipated energy is taken away, and, in that sense, the corals protect the shorelines from those breaking waves. And, of course, ... the loss of corals then leads to the increase in things like coastal erosion. As a result of that, there are also currents, as you mentioned, Melvyn, and currents are extremely important for coral reefs because they supply things like food. So there are deep water currents that move across our oceans, and when those deep water currents and deep water waves, when they bump into these giant underwater mountains that Steve is talking about, they also break. So you get these deep water breaking waves that force energy up the reef slope and can cause localized upwelling and bring that cold, deep, nutrient rich water to the shallows to feed the corals. Currents also supply larvae across the ocean and connect reefs to each other that way as well. And the diversity patterns that we see on coral reefs are somewhat reflective .. probably of historical current patterns delivering little larvae to different parts of the world.

[Melvyn Bragg] There's a phrase that came up ... when I was reading about this from what you three had written, that this was "teeming with life *in a sterile sea*". Can you just tell me more what you mean by that?

[Gareth Williams] Corals exists in this sort of oceanic, barren landscape, this oceanic desert. And Darwin talked about this, [sailing] for weeks on end, seeing these ocean deserts and then coming across one of the most diverse, if not the most diverse, ecosystem he'd ever seen. It was puzzling. The actual technical term is called the "island mass effect", this idea that there are these interacting forces that occur that actually increase primary production, increase little microscopic algae in the waters, the surrounding waters of these islands, to create little halos of production. So when you look at these oceanic deserts, there are these little pockets that are hugely productive, and it's because of these nutrients coming up from upwelling, it's from fish pooping in the water and birds pooping, and all these feedbacks that occur just from the fact that the island is there, river outflow if it's a high island. And so it increases this primary production around the island and can cause these little pockets of diversity.

[Steve Jones] It's interesting when you look at a coral atoll... when we have this image of Desert Island Discs and so on, of this heavenly place, which I can assure you that coral atolls are not ... in many ways, but the actual lagoon and the inner slope of the reef are boring places. There isn't this constant input of nutrition that comes in on the ocean currents. There's far fewer fish in there than on the ocean sides. So that when we imagine living on a coral atoll, we're actually missing the interesting stuff, which is the stuff on the outer reef, which you may not visit or even see. So they're very strange and isolated and interesting closed communities. And like many of those communities, of course, they're extremely fragile. It's a pity there are so few of them. And it's even more of a pity that there will be a lot less in the near future.

[Melvyn Bragg] While I'm with you, Steve. Looking at what's changed over time, can you take us from Captain Cook what he noticed about coral islands when he was in the Pacific in the 18th century to today? What's a major change?

[Steve Jones] Well, of course, there's been a complete upheaval in our understanding of coral reefs. I mean, Captain Cook was trapped behind the Great Barrier Reef and he had no idea that he would actually get a continent surrounded by a sort-of protective wall of rock and he got trapped behind that. In fact, he was almost wrecked. The Endeavor, ... his ship, went to ground on the coral reef and in fact, he threw over - to escape from it from it before it sank -... a number of cannon and anchors and the like, which were rediscovered a few years ago. So if you want to look at Captain Cook's cannon, they're in a museum in Sydney, I believe. So I think understanding of reefs has been completely changed in some ways, thanks to Darwin. They had an effect in making us realize that tiny, unimportant, apparently unimportant creatures like coral polyps can have an enormous effect. Karl Marx had comments on it in Da Kapital, and you don't often see that, he writes, "We see mighty coral reefs, but each depositor is puny, weak and contemptible". And he makes the case that ... puny, weak and contemptible individuals, like humans, when they cooperate with each other, can make massive structures like the Barrier Reef. So being Karl Marx, of course, he took a political message from biology, which I think in general is usually a mistake.

[Melvyn Bragg] And I don't like being lumped as puny, weak and whatever else he said about the same. Never mind. Nicola, what clues are there that some corals are more robust than others in face of climate change?

[33:44]
[Nicola Foster] Well, there are a number of clues. So climate change is causing the atmosphere to become warmer and it's causing the sea surface temperatures to become warmer, which is causing this bleaching that we talked about earlier when the corals lose their algae. But what we see is that the corals vary in their susceptibility to this bleaching, which tells us that some corals are perhaps more resilient or more robust than other species or other individuals. So the fast growing species with branching growth-forms tend to bleach first if the sea surface temperatures increase, whereas the slow growing species that have a more boulderlike growth-form, they tend to bleach later or they don't bleach at all. So that suggests that these are more resilient. And so there are these natural differences in individual coral species that give them this inherent resilience. And in addition to that, what's also been found is that corals can actually become more tolerant of bleaching stress if they're actually exposed to these warmer temperatures. So if you have coral species that live on the shallow reef flats, these are actually more often able to tolerate higher water temperatures compared to individuals of the same species that live on the deeper reef slopes. And so it's these conditions that the coral develops and grows in that can actually influence the conditions at which it will bleach, and it provides these corals with its natural resilience.

Thank you. Gareth, what impact can conservation efforts have on corals? Is there a one size fits all approach?

[Gareth Williams] I would say there's evidence showing that if you mitigate local stressors, local human stressors, the sorts of things that we've been talking about like fishing and nutrient pollution, ... there's evidence that reefs can recover more effectively following disturbance events, things like ocean warming events triggering these mass coral bleaching events. And a common approach for people to do this has been through things like marine protected areas. So, some kind of fisheries enforcement or regulation of activities within an area, or potentially fully closed off marine protected areas. The problem is that, ... as a conservation strategy, ... reefs are now shaped by multiple cross scale human impacts that can operate at global scales. So what I'm talking about there is that decisions made by banks, for example, or trade agreements made in one country can impact reefs many thousands of miles away. So these stressors, these sort of things like climate change, they don't recognize a marine protected area boundary. Ocean warming doesn't get to the edge of a marine protected area and think, "Oh, I better not go in. I might get fined." It doesn't work like that. Right? So that's a huge problem in the way that we've been thinking about how to protect these systems. And also, I'd like to come back to that point I made before, which is this idea [that] the time between disturbance events is becoming shorter, that there's this lack of time for recovery. And I think what that means is that climate change means that everything we thought we knew about coral reefs and their effective conservation and governance really needs to be completely rethought in light of this.

[Melvyn Bragg] What about plastic?

[Gareth Williams] Plastic...there tends to be this war out there, doesn't it? Is it plastic or is it climate change? Is it climate change or is it plastic? And the two often butt heads, funny enough, particularly in the literature. And in fact, a PhD student of mine just a few days ago published a paper entitled the "Fundamental Links Between Climate Change and Plastic Pollution". And it's because the plastic production, of course, contributes to global climate change. Generating all the plastic that we make contributes to greenhouse gas emissions. The destruction of plastic contributes to greenhouse gas emissions. So they're actually quite intertwined. Whether or not plastic has large scale, direct impacts on marine life, I think is still out for debate. ... There's certainly evidence that at local scales, plastic can be ingested by marine organisms and cause them ill health. We've done some work looking at the ingestion of micro plastics by tiny little coral reef larval fishes that in the first few days when ...nutrition is so vital for their survival that they're consuming these non nutritious, toxic-laden particles, it can only probably be a bad thing. But evidence for that scaling up to impact populations, I think, is still out for debate at the moment.

[Melvyn Bragg] Steve, at the outset you mentioned that Darwin's examination of coral showed that slow changes could have enormous consequences. Do you think what's happening is that coral reefs are dying off... slowly changing backwards, as it were?

[Steve Jones] Well, they're dying off pretty fast, if the truth were told. They're sometimes called, in a rather banal way, the rainforests of the sea. But there's much more rainforest than there is coral reef, so I think we need to be much more careful of them than we usually are. The other thing about them is there's an awful lot to be learned from the animals that make them - the polyps. I mean, most people at school would have looked down a microscope and seen this little hydra, as it's called, a little tiny, often greenish creature with its arms flailing around. And in fact, I vividly remember doing that; I couldn't be much older than 13, I would say. I had a rather good biology teacher and it seems perhaps an overdramatic thing to say, but it was that moment I was so amazed by this, that at that moment I made the decision I would become a biologist, maybe somliminally, maybe not. And it's a decision I haven't regretted for an instant. But ... just to see these things as a young person can be a very, very stirring thing. And in some ways, I guess we've had too much of it now. I used to watch David Attenborough programs; I used to be riveted by them; now you can't turn the television on without seeing yet another wonder of nature, reefs included. And there's a limit to one's power of wonderment. And I think perhaps to talk about the amazing properties of the animals that make the reefs would give them a new interest. Hydra, which is a relative of the reef animals, is immortal. In Edinburgh, where I was a student and there was a display cabinet of sea anenomies, it was set up in about, let me think, 1880. And when I was a student there, somebody knocked it over and these creatures had been in this little tiny environment, happily multiplying themselves for 80 years and would have gone forever, probably, till somebody dropped this, until somebody knocked it over. So the polyps are actually immortal. And you could take a polyp, a little coral animal, and you can cut into two and you'll get two polyps and so on. But the one thing that tells you something very fundamental about life in general is that the polyps are immortal but as soon as you get sexual reproduction and you get the sexual phases, which are effectively the jellyfish, they die. So sex, age and death go together. So next time you look at a jellyfish, your heart should sink.

[Melvyn Bragg] Nicola, what does the health of coral reefs tell us about the health of the ocean more widely?

[39:47]
[Nicola Foster] I think the health of the reef can tell us a lot about the oceans in general. Coral reefs are very sensitive to even the smallest changes in temperature and water conditions and pollution. And so I think they can give us an early indication of things to come, of what's happening in other areas of the ocean, perhaps further offshore or in deeper areas. And because coral reefs, they're located close to the shoreline and in shallow water, they're really visible, and so people see them frequently and we can see what's happening to them. And we can then use this information to give us an indication of what's happening in oceans in general. And we can use it like an early warning system, like a monitoring system. So as we observe the reefs and we see what's happening on these reefs, so if we see coral bleaching, we can detect that something is wrong in the ocean, and it can demonstrate that there may be something wrong in other areas of the ocean, so further offshore or deeper areas that we can't really see. And so reefs really are an important indicator of the health of the oceans in general.

[Melvyn Bragg] Finally, Gareth, Gareth Williams, what gives you hope ...for the coral reefs? Is there enough of them ...in ... robust shape? Does hope temper fear?

[Gareth Williams] Well, I think, I mean, as Nicola and Steve have pointed out, you know, there are so many things killing reefs. But I think that despite this widespread mass coral death that we're seeing across many parts of our planet, there are lots of corals still alive, tens, maybe hundreds of billions at least. And we can save these individual corals and the coral reefs they build, I think, for future generations. But we need to act quickly, and I think we need global cooperation and very strong leadership to reduce greenhouse gas emissions, the things that are principally driving global climate change and causing these mass coral bleaching events. The demise of coral reefs is the result of poor governance in my mind. But there are voices out there calling for change at the moment. I feel there's a momentum, perhaps more so than ever. And I'm not just talking about scientists, I'm talking about members of the public. But we are running out of time and we need to act now.

[Melvyn Bragg] Well, thank you very much. Thank you. Gareth Williams, Steve Jones, Nicola Foster, and our studio engineers through Mayo

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And the In Our Time podcast gets some extra time now with a few minutes of bonus material from Melvyn and his guests.

[42:06]
[Melvyn Bragg] What would you like to have said that you didn't get time to say? Who wants to kick off?

[Steve Jones] Can I talk briefly about the coral animals themselves?

[Melvyn Bragg] Yeah, you talk as long as you want...

[Steve Jones] They're fascinating...fascinating animals. The coral animals are the most primitive creatures that we know that actually go to sleep. Okay? They actually do cease their activity on a 24 hours basis. But what's striking about them is that they're a kind of microcosm of development because they develop into this into this structure, and they're stem cells... the coral animal cells are stem cells. Most people have heard of stem cells now, in other words, you've got cells in your bone marrow, which are stem cells which will generate different kinds of white cell and red cells and that kind of stuff. But most of the cells in a hydra, shall we say, or a coral reef polyp, ...they're all stem cells. So that people who are interested in stem cells, because of their importance in human health, shall we say, or in cancer, are actually beginning to concentrate on the cells of the coral animals and to look at the genetics of it. And this just shows the amazing connectedness of biology as a science... It's astonishing to me that you can perhaps, perhaps, find a cure for cancer by understanding the life and death of the stem cells of the coral animals. But this is certainly possible. So that I get very tired of people who used to say, they say it less now, ... what you biologists or you scientists need to discover next is the following thing. Okay? It's not like that. ...Good science has always seen the triumph of the unexpected. Something suddenly turns up. You didn't expect it, and you have to be able to spot it. And I think the story of coral is a classic of that particular phenomenon.

[Gareth Williams] I completely agree, Steven. And we're still discovering, as you say, so much about the coral animal. I mean, to pick up on a point earlier about the reliance on photosynthesis by the coral holobiont, you know, the fact that the zooxanthellae is photosynthesizing. It's only recently we've actually started to realize that in some cases the corals are relying much more on predation - on the heterotrophy part of their mixotrophic lifestyle. Relying on that predation on things like plankton far more than we perhaps first thought, and I'm talking here about corals living in shallow depths where there's plenty of sunlight. People using new stable-isotope-type techniques, to track energy flow and where the corals are actually obtaining their energy, are finding that some corals meters apart, some are almost entirely photosynthesizing, and some are relying 80%, perhaps, on predation. Just a few ...just on very small spatial scales. And people are now wondering whether this would help to explain some of the patchy mortality we see during bleaching events. Because if you predate a lot as a coral, of course you can store a lot of lipids, and those lipids can help you survive periods when you've lost your zooxanthellae. If you have more lipids, you can perhaps survive for longer. So it's incredible to me, as Steve says, that we're still learning about what would be considered perhaps the basic biology of the corals. We still don't even really know which is the weakest link - the coral or the algae - during coral bleaching. It's still debated, actually, by scientists. It's amazing.

[Melvyn Bragg] Nicola?

[Nicola Foster] No, it's all fascinating and, yeah, absolutely right, Gareth, that we still don't know what really is driving that bleaching. Is it the host coral ejecting the algae, or is the algae leaving it of its own accord, or is it a bit of both? And it's just fascinating that we still have so many questions that we need to answer. And what you were talking about in terms of certain corals on the reef using heterotrophy more than the food source from the algae itself is quite interesting. And I wonder if, as you said, the variation in mortality after bleaching, is it specific to certain species or certain growth forms? So we see that the branching corals bleach earlier and are more susceptible to bleaching. Are these the ones that rely more heavily on photosynthesis, whereas the boulder corals that are more resilient to bleaching, do these rely more heavily on heterotrophy, or is it just a mix?

[Gareth Williams] I was going to say, Melvyn, the other thing we touched on very briefly was the idea of disease. I think it was Steve that mentioned it, and it links to medicine, and we talk a lot about coral bleaching, but of course, corals suffer from other diseases, just like we do, that are caused by pathogenic microbes, bacteria, viruses and things like that. Sadly, not to be more of the doom and gloom, but for some of those reefs that have been hammered by these mass-bleaching events, places like in Florida for example, they're now being subjected to these large disease outbreaks. So those corals that have survived these bleaching events, some of them are now succumbing to these diseases, some of which people think are caused by bacteria, which, of course, are becoming more virulent. So they're able to take hold of the coral hosts more effectively under warming temperatures. That's why you put food in the fridge, of course, to hold that bacterial growth. Some of these diseases are causing this necrosis of the coral rapid tissue death. And what's so sad is that some of these diseases are killing corals over days, and some of these corals might have taken tens of years to grow. So I think it's important that we also remember that there's these disease outbreaks which are also contributing to the death of corals. But probably we can learn a lot about the disease ecology of the organisms by studying this.

[Melvyn Bragg] When you talked about Hawaii, Steve, I was fascinated to read more about it in your notes. I'd love to hear a bit more about it.

[Steve Jones] But Hawaii, as I mentioned, was tremendously populated and they lived on the marine environment and they actually conserved that marine environment with great enthusiasm. And there were constant battles in Hawaii. Hawaii was a very, very bloodthirsty place even before they killed Captain Cook. And a lot of those battles were about who owned the coral reef, who was allowed to go out and use them. And if you go down the great chains of reefs that have been, you will find that ... in the Pacific, there's been constant movement of populations along the reefs. And what they tended to do on the smaller islands that they would exhaust the reef and they were forced to move on. And in fact, this is what drew people in the end towards Australia.

[Gareth Williams] And so they played really quite an important part in human history when people were first exploring the oceans. One of the great threat to a mariner going across the ocean was, of course, a low lying submerged coral reef. If you were to run a ground, it would puncture the hull of your ship and there weren't coast guards back then to come out and get you. I'm talking about hundreds of years ago. And sailing across the ocean later at night would have been very treacherous around these tropical submerged reefs. And so they used to put people out on watch at night. And sometimes what those people were actually doing is they were listening for sounds. So if you can imagine just sort of staring out over a very dark night in the middle of the ocean, knowing that you might run a ground on a coral reef and what it might be that you were listening for, and all of a sudden you'd hear banging on the hull of the ship.

And that sound would have been the banging of sea turtle shells. The sea turtles are so numerous back then, prior to large scale human exploitation, that early mariners used to use them as a sort of early warning signal they were approaching these shallow grounds. And of course, at that point they would hold too and wake everybody up. And it just for me, highlights how incredible that the number of these large organisms there were once many hundreds of years ago before we exploited them so. And now, of course, most sea turtles are classified as endangered on the threatened species list.

[Steve Jones] The thing I like about reefs is if you want to visit a reef, you can see them in Britain. But Melvyn, I assume that when you were a student at Oxford, you used to go to Wytham occasionally. There's a nice pub in the village, you may remember?

[Melvyn Bragg] Yeah...

[Steve Jones] Well that's on a coral reef...

[Melvyn Bragg] Wytham Hill, as I've learned from your notes. I didn't realize I was having a half a bitter on a coral reef.

[Steve Jones] Yeah. And if you go to Malton in Yorkshire, which is a magnificent place, that too was in part a coral reef, so the corals are all around us. You don't need to go to the tropics, just get a bus, get to Oxford and walk up Wytham Hill, and you'll be on a coral reef - not quite as colorful as they as they are in the tropics, though that's arguably true.

[Melvyn Bragg] Well, thank you all very much. I'm sure that a lot of people will love that program. I did. Thanks a lot.

In our time with Melvin Bragg is produced by Simon Tillotson.