Q1: **Ngai pirrku mankulankula. Ngai nari Kumatpi Marrutya. Ngai wangkanthi marni naa pudni. Kaurna yarta- ana. Irdi yarta. Hello, it's Mickey O'Brien here Ambassador of the Kaurna people. And today we're on Kaurna country. And I'm known as the impatient one. So Ngadlu wangkanthi and Naa marni naalitya, Marni naa pudni parrku pirrku Warra mankunthi, Kaurna yarta. So we can say hello to you and we also welcome you to this podcast recorded on Kaurna Country.**

Q2: **Welcome to the South Australian Museum Podcast. I'm your host Meg Lloyd and I'll take you through the curious and complex collections of the South Australian Museum. One of the museum's key tasks is creating a collection of natural history, but how do you define each item and distinguish it from the next? Finding a single definition for species is tricky. It refers to a rank in taxonomy, the classification of life. Cats are one species, Felis catus. Dogs another, Canis familiaris or Canis lupus familiaris if we define them as a sub-specifies of wolf. How do you decide what counts as a species, and once that is defined, how do you identify the creature in front of you and which species it belongs to? Thankfully, we have a lot of scientists working on these problems. Shall we talk about this thing that's on the desk?**

P1: Yeah, I can't remember why I got the, besides that it's really cute.

Q2: **Well, really cute. So the jar is - - -**

P1: They are adorable.

Q2: **Inside the jar is a collection of, I don't know, maybe 30 very small mammals.**

P1: Pygmy Possums. I've remembered what they are.

Q2: **Pygmy Possums are exactly as they sound. They're a type of possum, they're only about 5 centimetres to 12 centimetres long, including a long tail. It's a possum that fits in your palm. I recommend a Google image search. They are cute. They are also dead.**

P1: They are adorable.

Q2: **You may remember Keith Maguire from Episode 3, where he talked about his work in maintaining the database for the museum's vast collections. He's not a scientist, rather an expert in data management and a person who shares my curiosity about museum objects.**

P1: So the reason I took this out was to show that we often collect the same thing again and again and again and again. That can, on initial impressions seem to be rather wasteful, because why are you doing that? Why do we need 30 of these adorable little things dead in a jar? The reason is, what's different from a museum collection to a sightings or a textual description is that here's the proof that these animals existed in a place at a time. The proof with sightings or with literature, someone says it, but if you want to actually verify for a fact that there was a particular pygmy possum in a particular place, we've got it. You can come and verify that it was the animal you said in the place. So the evidence that there was this particular pygmy possum was collected in 1922 in – I'm just trying to turn it around to see whether I can read the label, and that looks like Albert Hill – you can come and look at it and you can do analyses on it. You can examine the specimen and make sure it really is what the people thought it was. A suspicion can be confirmed by looking at the specimens, where when it's suspected that there was more than one type of animal that was previously described as the same type of animal. You can just put them in a table and look, that's a gross oversimplification, but that's a lot of the way how new species are described. One of the ways that the general public are made aware of biological collections in museums is when it's broadcast that a new species of something

have been found. That the museum staff who work in biological collections, that happens all the time, constantly.

Q2: Dr Shirley Sorokin has had a long career in both research and science communication, including using marine invertebrates for medical research. She's an expert in temperate and tropical benthic invertebrates, i.e. the creatures at the bottom of the sea, especially sponges.

P2: Hi, I'm Shirley Sorokin and I'm a collection manager in the Marine Invertebrate section at the South Australian Museum. One of the reasons that the collection is here is for researchers to borrow things out of the collection. So we lend a lot of our specimens to international researchers and researchers around Australia, so that they can work on the taxonomy of certain groups that they might be interested in. And that's one of our roles, is to answer a lot of queries from researchers and provide them with the material they want. We have another role in that we answer public queries as well. There are a lot of public queries that come into the museum, and if they can't be answered in the discovery centre then they're sent to us to try and help people, to give them names for things they found on the beach for example. In 2015 we collected a lot of specimens from deep sea, and the new sponge that I described and named from that collection I named after my mum. And it's not a normal thing to do, to name a sponge after your family member, but I was lucky in that my mum's name was Iris and the genus of the sponge was Tethya, and the Goddess Iris was Tethya's grandchild in Greek Mythology. So I had another reason to name the sponge after the name Iris. So the sponge is named Tethya irisae. The Goddess Iris was a goddess who had wings and could move very fast all over the world, including getting right down into the deep sea. That's what it says in the Greek Mythology.

Q2: Have you named species?

P3: Yeah, it's fun. I'm Steve Donnellan and I have responsibility for the research and collections part of the museum, the staff and all the collections in the buildings, and the activities that come out of that group, which is our research output publications, and contribution to our public programming and exhibitions. And of course, the really fundamental thing is looking after collections for as long as the planet exists.

Q2: How do you pick the names?

P3: Well, there's sort of two schools of thought. One is that you would name it after some feature that would help you recognise the animal. But animals have a limited number of features on them. So if you've got 600 species of microhylid frogs and they all look pretty much the same to each other, or a hundred of them look very similar to each other, you can't keep using features because there just isn't enough features on a small frog. So some people might use a name for the geographic region where the distribution is mostly encompassed. The other school of thought is you might name it after people, who have done important work or have supported the research in some way or another. So I don't have a strong opinion one way or the other. There are strong traditions in both those schools. There are some people in the past who propose that we use the same system that the safety industry uses to name radio beacons, which is basically they have a computer program that generates pronounceable seven letter names. So there's no committee that decides about whether a name is acceptable or not; that's really, if you like, a Scout's honour type thing. There is a committee that helps people decide whether names that have been used previously in literature apply to the species that you're working on. So in the past, and we're talking a couple of hundred years now, people have been using this combination of two names, the genus name which has a capital letter for the first name, and then the species name the second name which begins with a lower-case letter, to be the official scientific name of species. There are many, many, many publications that have created new names for species where the

description is so poor that we're not certain to which species it actually applies. Or the specimen or specimens that were used to name that species have been lost, because they might have been in a museum in Berlin that got bombed during the Second World War. Or they were thrown out because they were thought to be not terribly special specimens. Or they were mounted specimens and got so flea bitten and degraded that the museum threw them out, because there was basically just the wires and the wood left that was used to mount them. So there's a whole range of reasons why we might not be able to relate the name to the specimen or the species. In which case it might be a lot of work to do that, we may not be able to do it. And so the fact that the name exists previously creates what we call a precedent. And the International Commission for Zoological Nomenclature gives us guidance on how to deal with those names that existed previously and how to deal with them if we can't associate them with a biological entity that we now know it's the reality for it.

Q2: Potential distraction or degradation of an object is one of the reasons we have a system for cataloguing multiple specimens, as Keith explains.

P1: One of our jobs as a museum is we care for the type specimens of taxa. When you read or hear in the news about a new species, what that means is that someone has kind of said, if an animal looks like this you should call it this. But it's not just that; they say if it looks like this, and they describe it in great detail and there will be illustrations of the particular things that make this species different to closely related species, but then what they'll also do is they'll nominate what's called a holotype. So the holotype is, I think the term is the name-bearing specimen. And what it is for an animal to be that type of animal, is that it resembles that particular exact physical specimen. So what makes a dog a dog is not that it's furry and has a leg at each corner and barks. What makes a dog a dog is that it physically resembles a specimen in a museum somewhere that is the holotype of Canis, whatever the scientific name for dog is.

Q2: It's Canis familiaris.

P1: So if I show you an example. I have in front of me some adorable little frogs, and this jar contains a holotype and one, two, three, four, five paratypes. They're very small frogs they're, what would you say, a centimetre long? Adorable little - - -

Q2: No, they're two centimetres long, I reckon.

P1: Okay. I'd say they're about two centimetres long. The holotype is number 1866, that one at the bottom. So for a frog to be one of these types of frogs, is that it physically resembles that particular individual frog. If the unfortunate were to happen and that particular individual frog were to be damaged in some way, or let's say its fingers were particularly distinctive and it lost its hands. Then you'd go to the secondary backup types, which are the paratypes. So the paratypes are specimens that the scientist has said, look, they're the same as the holotype, but they're not the holotype but they're the same as it. And what you do with the paratypes is you send them around, so there's a backup system. So the holotype is here, the paratypes are here, some of the paratypes are here. Others will have been sent to other museums, ideally around the country and around the world, so there is always a backup system so you can still verify that an animal is that type of animal. Then what will happen over time is someone looks at the types of two ostensibly different animals and goes, wait a second, they're the same. And then one of them will become, or a new example will become a new holotype and the old name gets synonymised with the new name and basically they're saying don't call it that anymore, call it this. And that's the process of taxonomy and taxonomic revision, and it goes on all the time. It's one of the central things that museum biological collections are used, is simply for saying all the different types of things and giving them names, because if

you don't give them different names you don't know what you're talking about, you don't know what – that they are different things.

P4: So a key is something that a person with some knowledge of small mammals, in this case, can use to identify down to species something that they might have in their hand, whether they're out trapping or they find a dead something or other, whatever. They want to find out what species it is. And some of these small things are really hard to identify. Taking a photograph of them is often not good enough. So you have to look at little details of feet and hairs and all of those things. I'm Catherine Kemper, I'm the Senior Researcher in the mammal section at the South Australian Museum. I'm a general mammalogist, so I do terrestrial as well as marine animals. When I was a child – I think it's in my genes to love natural history. So some of my earliest memories as a child are little animals. So it was in there. And very much encouraged by my parents actually, they were wonderful to encourage my love of nature. I ended up at the South Australian Museum in 1983, so I was very fortunate to get a job, a really good long-term job that I could get my teeth into. It's so unfortunate these days how young people in all fields, but particularly in science, are just getting these short-term jobs. They can't do the bigger picture, longer-term work as easily, because it's from three or five years to another three or five years. So about 20 years ago I started to work on these keys, and I had a lot of the words pretty well in order a long time ago, but I got stuck on how to illustrate them. So, traditionally, keys in the past have been illustrated by little diagrams, little black and white diagrams of whatever you want to show, whether it's a foot pad or whatever. Scientific illustration is a very difficult thing and it requires a person who really knows that trade. And so for me to illustrate using really beautiful diagrams would have cost a lot of money to get a proper scientific illustrator. So Mark Hutchinson, my colleague next door who's the herpetologist here at the museum, had this wonderful idea a few years ago to use photographs, because he's done that for his keys to reptiles. So he suggested Paul.

P5: Hello, my name is Paul Stokes. I'm general dogsbody and photographer for various people, taking photographs of whatever appears in front of me on any particular day.

P4: And so Paul and I started to do the photographs, and I mean that's taken us a few years to do, amazingly, once a week pretty well we would get together and do this, and we've used specimens out of the mammal collection at the museum to illustrate this. Ideally it would be wonderful to use live animals or not fixed animals, or dried animals, or whatever. But that's not just not possible to do in this amount of detail. So we are using specimens out of the museum's collection. Which is wonderful to have.

P5: And trying to photograph moving animals is extremely difficult, it's far better if they're dead to take the photographs. So when we started this we actually tried to use cameras that are here. But we weren't getting a sufficient level of detail into the pictures that we were taking. So I had a camera system at home, and one of the features is that you can do focus stacking. Basically what it does, it will take eight or nine photographs and then composite them into one picture. So you get all the detail that's there.

P4: Okay. So depending on what we wanted to photograph, whether it was a little foot, or the whole animal, or the tail, or whatever, I would go to the collection, so I would look for the species that I wanted to illustrate in this key. One of the real tricks was I had to choose animals that had the feature clearly visible, say in a foot or whatever, and I had to have it so that the foot wasn't all screwed up in a little curled position, because then I couldn't see or Paul couldn't photograph the bit he needed to. So I would take a whole jar of some of these little things down to the basement and then have a few available and then choose the best one, and sometimes that didn't work either.

P5: Sometimes we simply had to say, okay, we'll come back to that at a later point, when we can find the same sort of markings perhaps on a different specimen. And then we had to arrange a framework on which to, should I say, lay the specimen out and hold it in the right position so that we could actually take the photograph. And sometimes a sort of, a bit of gymnastic work involved there in actually getting the specimen into position. But we didn't hear many complaints about it.

P4: Well the interesting thing was that we didn't have anything really high tech – I mean the camera was high tech, the lighting was high tech, et cetera, but in terms of getting the specimen in the right position, we just used whatever we had to hand. So we would maybe use a paperclip bent in an odd sort of position, in order to hold the foot or whatever in the appropriate position. So I'm doing them family by family. So the idea is that we are doing the keys to all the small terrestrial mammals in South Australia, making them available on the website so that scientists can use them, but also lay people can use them if they wanted to. Because as keys like this are used by many people, they sometimes give you – well, hopefully they will give me feedback and say, Cath, this doesn't work, or wouldn't it be better to do such and such away. So that's the beauty of electronic versions of these keys, because in the old days it was just print copy only, right, and then you'd really be stuck if you wanted to change it.

P3: Every species with a name means that we can talk to each other about it. We don't have to say, oh that frog from Iron Range, it's got small toe pads, black spots in the groin and doesn't call. That would be a very awkward way, instead of say calling it Litoria [00:21:18]. So when I started working here, the tools of DNA sequencing were just starting to become practical for non-medical scientists. So, basically, we went out and we collected samples that represented what we knew of the fauna, that was suitable for DNA analysis. And so that means that meant going out, trapping animals, euthanising them, take small

bits of tissue, putting them into a liquid nitrogen cylinder in the field, bringing that back and putting it into minus 80 freezers. And the South Australian Museum now has one of the largest wildlife tissue collections in the world. A thing we're very proud of. So we have now one of the best represented regions on the planet, in terms of both specimens and samples useful for DNA analysis. And that's a remarkable resource that we utilise every day and we send sub-samples of those to people all over the planet on a regular basis as well. Now we look around to filling in gaps in geography, where we might not have been to in the past, or as we do this DNA work we find there's actually a lot more species of animals out there than we previously thought, but sometimes they're really difficult to identify and we may need to go back and collect some more specimens to resolve that. But we also might then realise that there's areas of the state, the country, or our region, where there's a lot more species to be discovered, because we've just scratched the surface with our first field trip there. So now we're in the business of really going back and targeting the landscape in a much more direct way to try and fill in those missing, the missing catalogue of the life in our region.

P1: One of the tricky things is you don't know if we have a particular animal from a particular place because it's particularly prevalent in that place, or if we just happened to go there.

Q2: Oh, right.

P1: So that we didn't find an animal in a particular place could be that it's not there, it could also be that we weren't there. It could also be we just didn't find it. They're really sneaky.

P3: So you can examine biological phenomena and describe them. But you get the best perspective putting that in an evolutionary context. Because biology is not stationary. We view the earth and its fauna and flora and its history from the

lens of our lifetime, which maybe 40, 50, 60, 90 years. A very short period in the history of life on the planet. Evolution occurs short time scales and longer time scales as well. But to divorce what goes on now from those longer time scales is really, it's not really portraying science, the science life as it should be portrayed. So putting the guardianship of life on earth in an evolutionary context is really important, because we're handing it off to the next generation, each generation. And we need to build into that idea that life changes, and it changes with the climate, it changes with the interactions with other life forms, and it's not a static thing. So having that evolutionary context for how life changes, the underlying mechanisms is really important for biologists.

Q2: The SA Museum collection specifically, what does that teach us about environmental change?

P3: Well, that's where we open up the entire museum collection really. So we can see the broad-scale climate change the planet's undergone in the last half billion years. And then for the more recent period, since Europeans arrived, we can measure the change in distribution of animals, contractions of ranges, disappearance of populations, because our museum collections go back from not long after Europeans arrived in South Australia right through to now. We could also look at sediment samples and measure diversity through time; that would take us back to pre-European period. And then we can look at the DNA profiles and measure how that's had an impact on the genetic diversity of animals, both that climate change and human impacts have had on – well, humans are not disengaged from environmental change in the last couple of hundred years because of, well, carbon we've put into the environment. But before that we were changing the landscape, there were large presumably wholesale transformations of the landscape through firing practice, introduction of grazing animals, exotic pests like rabbits. So there's an ongoing history of environmental change which we can get from looking at the genetic diversity of the animals, looking at the fossil record, looking at owl pellet

deposits. Owls catch animals from the environment, they can't digest the fur and bones, they spit them out, owl pellets accumulate where the owls nest each day. And sometimes they're quite stable because they're in a cave, so you can actually go back a couple of hundred years and see how small animals have disappeared from the landscape, through the influence of grazing and land clearance. There's lot and lots of ways of detecting environmental change that our collections are useful for. So one very important, what we call environmental proxies.

Q2: We looked at proxies in Episode 4, where palaeontologist Dr Mary-Anne Binnie talked about how she used micro fossils as a proxy for sea levels. Here the fish ear, the otolith, acts as a proxy for the fish's age and location.

P3: So we're not measuring the environment directly, we can't go and measure the temperature a hundred years ago directly – sorry, I should say 300 years ago, a hundred years ago there would have been some temperature records. But we could look at fish. They have, it's not a bone, it's actually a bone-like structure in their ear called an otolith, which literally means ear stone. That grows in an onion ring-like way, so when the fish is really small it's very tiny, and then as the fish grows it deposits more calcium carbonate and other minerals in low concentration as a ring around the outside of the original otolith. And so by the time it becomes an adult, if you took one of those otoliths out and cut a section through it, it would just look like when you cut through an onion, if you were chopping up your onion for salad.

Q2: Or a tree.

P3: Yeah, that's right. And the inner bit was laid down when the fish was a tiny little lava. The outer bit was laid down just before you collected the animal. But technology is such now that we can use a laser to ionise the material in those individual rings. So if a fish lived in fresh water as a lava, and then sometime

through its life cycle moved to salt water, we'd be able to tell that because of the ratios of a couple of important elements like barium and strontium vary whether the fish was living in fresh water or salt water. And so we can actually trace the fish without having ever tagged it in the first place. We can also figure out how old the fish was, because we can count the number of rings. And for a fish living in temperate climates where you get a clear summer or winter, the fish grow quickly in summer and the rings are quite wide, and in winter it's a narrow ring because the fish is growing slowly, because it depends on the temperature. So each pair of rings, a wide one and a narrow one represents a year, roughly. So if you count the number of pairs of rings it tells you how old the fish was. And if you find the part of the lifecycle where the fish went from fresh water to salt water you could tell how old it was when it did that as well.

Q2: And you don't just learn about the fish from the otolith, you can learn about the environment the fish was living in; that's why it's a proxy?

P3: Yeah. So you get that environmental signal from those trace elements that vary in concentration, depending one's who are in salt water or fresh water. And in fact some fresh water bodies have different signals too, because the catchment comes from a different sort of rock, so it has its own particular environmental signal. So you might be able to trace where a fish came from originally, which fresh water system, which major river system it came from as well. So it's remarkable what we can do. And this is all technology-dependent and a hundred years ago people would have – this would have been the Star Trek of a hundred years ago. So the reason for having this museum collections is what we can do with them today, but also what we might be able to do with them 10, 50, or 100, or 200 years. That's something I guess a lot of people might not appreciate. That the longer we have a museum collection the more valuable it becomes. Because it's further away from when we can go back and collect material that's in the past. We can't go back a hundred years and collect fish now. We could maybe go to a stream where there's some 10-year-old fish now.

But we're not going to be able to go to a stream and find many fish that are a hundred years old. So having that material and keeping it, it becomes more valuable every year we keep it. And so in a museum, collections don't depreciate, like the rest of the assets on the planet, in an economic sense, they actually become more valuable and phenomenally valuable the older they get.

Q2: **Thank you for listening to the South Australian Museum podcast, hosted by me Meg Lloyd and recorded on Kaurna country. Original theme music (? Peter) (? Saunders) [00:31:11], audio production by (? Jake) (? Holmes) [00:31:11]. This podcast series has been made possible by the support of National Science Week, see their website www.scienceweek.net.au for amazing science events happening all over Australia. This is the last in our collection stories series, but we'll be back soon with more insights into our research and behind the scenes peaks into the collections. Please subscribe on your podcast app so you'll receive all our updates, and please get in touch on social media, or email programs@samuseum.sa.gov.au to tell us what you've enjoyed about the podcast and what you want to hear more of in the future. Thank you to all of the SAM staff who trusted me to record their stories. For more information about our museum please visit our website www.samuseum.sa.gov.au. Ngaityalya Nakutha. Thank you. See you later.**

END OF RECORDING: (32.00)