Environmental enrichment: why it is important for zoo animals
環境エンリッチメント：なぜ動物園の動物にとって大切か

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Thank you very much. So, it's a great pleasure to be here. This afternoon, I'm going to cover four main topics. But, my first topic is how scientists assess stress and welfare in animals. And this is important, if we were to make decisions based on our heads, and not just our hearts. Then I'm going to talk about what captivity means for wild animals. Then I'm going to talk about what we know about the value of environmental enrichment. And then I'm going to give you some speculative information about what studies of laboratory animals suggest might be mean functions of environmental enrichment.

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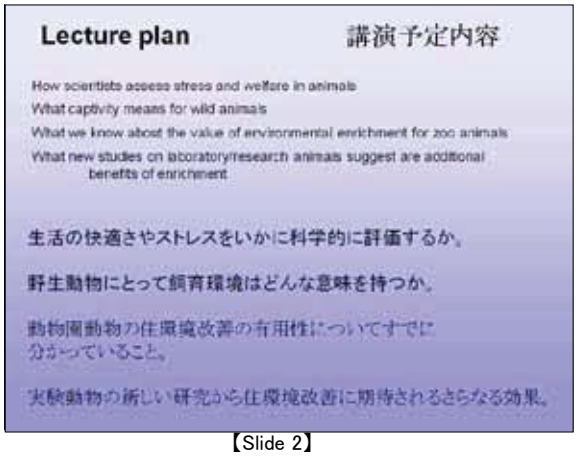

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So first of all, let's cover how people doing science assess animal welfare. And, the techniques people like me use for accessing stress and suffering in animals mainly come from looking at stress and suffering in people. So, we can look at humans having a terrible day at work, and we can look at humans for whom the work stress never stops. We can look at people having an argument, or we can look at people trapped in a bad relationship. We can look at somebody crying. We can look at somebody who's depressed. We can look at somebody who's very frightened, and we can look at somebody for whom the fear goes on and on. And in people going through these states of bad welfare, we can measure many things that change in their bodies.

We can look at their hormones, we can look at their immune systems and we can look at their behavior. And these measures give us measures to apply to animals.

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So what do we see? We typically see agitated, restless behavior. We see very strong desires to change the situation. People want to escape. We see depression,

anxiety.

We see stress hormones being released, like adrenaline and corticosteroids. We see problems with reproduction, infertility, infant death.

We see immune problems, and consequently we also see high rates of disease, stomach ulcers, heart disease, and even shortened life spans.

So all these are measures we can look at in animals. And I want just focus on two of these to explain them in a little more detail.

The first is agitated restless behavior. So if a normal human being is stressed, we might see things like, you bite your nails, or you may pace, or you may move your knee up and down in a restless way.

But if you're a human with a clinical condition like autism or schizophrenia, then we see stereotypic behavior which is very abnormal, very heavily repeated behavior. So on the left, we have a small boy with autism who is waving his hands in a stereotypic way, repeatedly.

And these are similar to what we see in very damaged animals. So, here we see a monkey taken from its mother very early, and again we see these very strange behaviors when the animal is stressed. And another measure I just want to explain in a bit more detail, is the stress hormones.

So these are adrenaline and corticosteroids.

Here we have the kidney, and above the kidney is a little gland called the adrenal glands. And when we are frightened, our brain sends a signal, and the adrenal glands releases these hormones.

Okay, so now I'm going to spend a while talking about what captivity means for wilds animals both, in a good way and in a bad way. So, the important thing to realize is that for a wild animal, captivity have some advantages; it's safe, they have plenty of food. But, it has disadvantages as well; it can be very boring and the animals are physically restricted. So how do these advantages and these disadvantages balance out? Well, life in the wild is certainly very tough. Animals have to look for water and food.

So this little bird here has to eat insects every few minutes or it will starve, these deer are trying to find food in the snow, these foxes are trying to find water in a desert. Life is tough. And so for many animals, being

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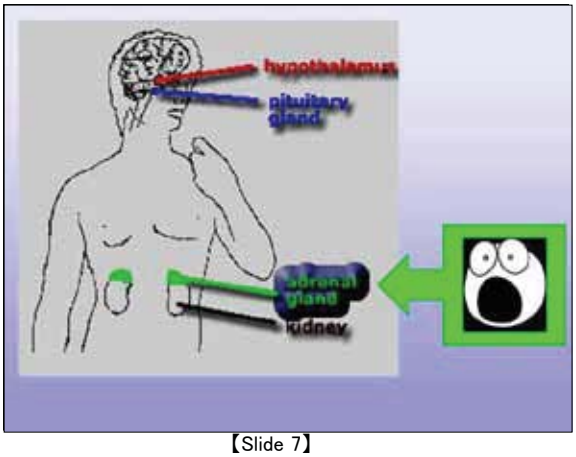

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in, looked after by humans is wonderful.

They have food given to them, they're safe, they have good health care. And this is true, not just for

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domesticated species, but for some wild species as well.

So just to give you some examples of species that do very well in captivity, grizzly bears do wonderfully in zoos.

They don't show abnormal, stereotypic behavior, they breed very easily, and their infants survive very well. So they seem very happy in captivity. And there are several other species that seem very happy in captivity as well.

The Arabian oryx is one. The rhesus monkey is another. The Ring-tailed Lemur does very in zoos, and so too does the Norway rat.

But we all know, sadly, that this is not the whole story.

And that for some animals in zoos, captivity really is a problem, and we see bad behaviors like this stereotypic behavior in a bat.

So I want to talk now about some of the problems we see, and then maybe how we can solve them.

So first of all some of the problems we see are stereotypic behaviors which are these very repetitive, unvarying behaviors, very similar to like what we see in people with autism. So here we can see two bears pacing. Here's a jaguar pacing. And here this elephant is doing exactly the same movement each time, so it puts its foot in exactly the same place each time it goes

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round and round. So these behaviors are a problem. And in some species, these stereotypic behaviors are very, very common. So for example, in giraffes in zoos, 80% of the animals do stereotypic behavior.

They do strange movements with their tongues; they stick them out, the move them round and round, they lick the wall, or they lick other objects in their

enclosure. In other species, stereotypic behavior is also common and we see other problems as well. So for example, for both species of elephants in zoos, there's many reasons to be concerned about their welfare. Once again, they show stereotypic behavior, So this again, here we see swaying, and on the right we have the video I showed you before. But we also see other problems as well in both species of elephants in zoos, and we'll hear about some solutions later this afternoon. Across the elephants in zoos, we see veterinary problems like lameness and skin diseases. Animals may kill their own babies, commit infanticide. Other animals may be infertile and elephants often die prematurely. So for Asian elephants in zoos, they live half as long as they would if they were working in a timber camp, if they were in their wild country.

Cheetahs are another species that often have problems in zoos. So, one problem we see is that they produce lots of stress hormones. If you look at stress hormones that are excreted, you see they have very high stress hormones compared to animals in the wild. And because of this, their adrenal glands, the glands that produce the hormones, become very enlarged. If you look at the adrenal glands from a cheetah in a zoo, they are maybe four times bigger than the glands from a cheetah in the wild. And because of these high levels of stress hormones, they are very prone to problems with their stomachs, gastritis and gastric ulcers. And on top of these problems, we also see reproductive problems in zoos. So for example, when they breed their babies are very at a risk of dying early and infant mortality rates are twice of what you see in breeding centers in Africa.

It's not all bad news, however. So, how animals adapt to captivity, how they adapt to zoos is variable. It varies across species, it varies according to whether it was captured from the wild or brought into a zoo, and it also varies with what the zoo is like. So I'm going to give you some examples and then show you how this can help us identify solutions to welfare problems. So here is one example of variation between zoos. So I told you that infant mortality is high in this species, the cheetah, but it's very variable between zoos. In some zoos it's quite low, at just 17% in the first six months. In other zoos it's very high with nearly half the infants dying before

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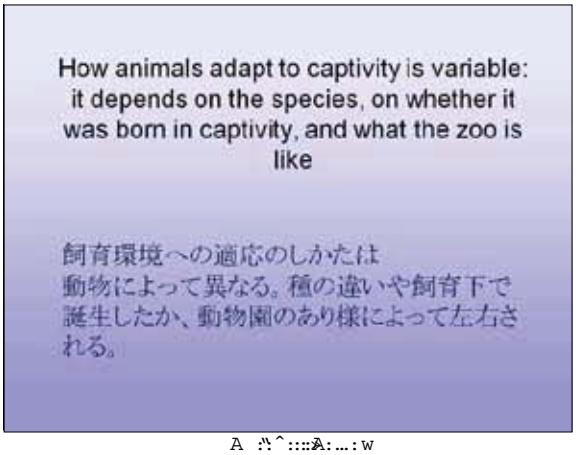

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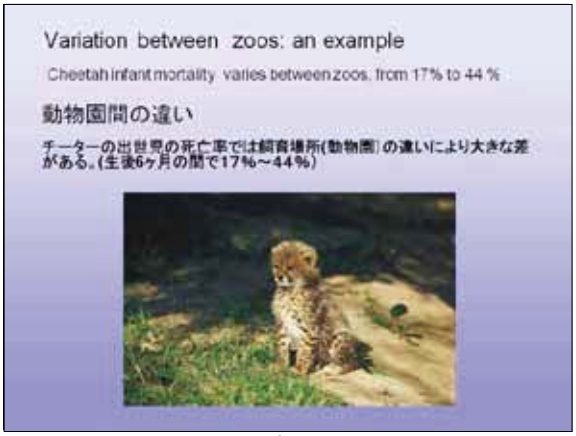

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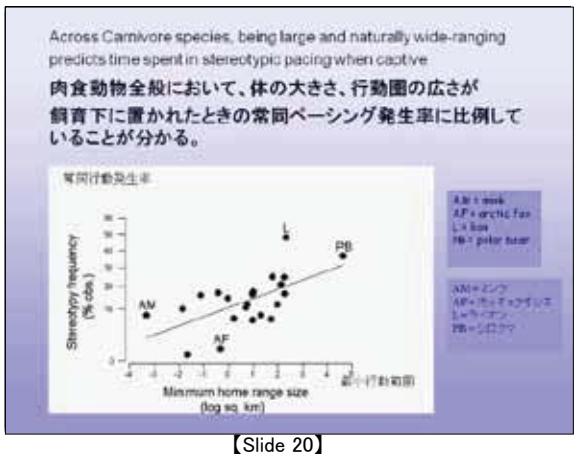

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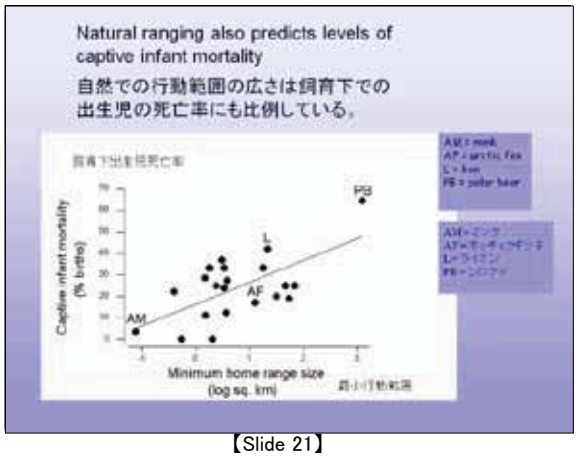

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they are six months old. So some zoos are getting it right, some zoos are not. We also see variation between species, with some species doing very well, and some species doing badly. So on this slide, the bottom row all tend to do well in captivity, and the top row tend to do badly.

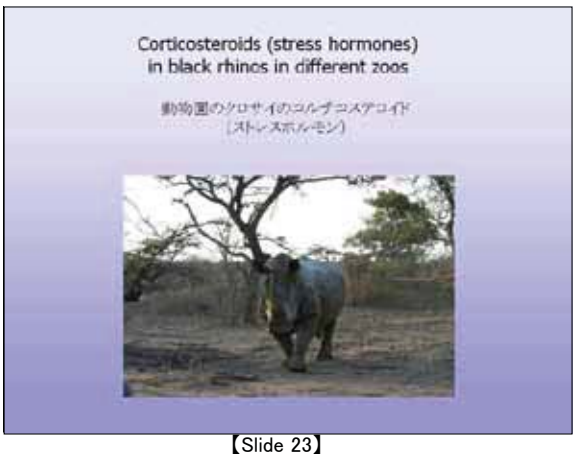
So these species don't show abnormal behavior, their babies survive well, the animals breed well, and the animals typically don't have many health problems. These related species tend to have health problems, abnormal behavior, and lots of other symptoms of stress. So we can use scientifically, we can use the variation between species and the variation between zoos to objectively identify the origin of welfare problems.

So here is one example. Across the species of carnivore we can see that lots of the variation in welfare is caused by variation in their natural biology. So on this graph, each dot is a different species. And here we have stereotypic behavior, how much abnormal behavior they show, and here we see how big a home range they have in the wild. And this graph shows us that species with small home ranges in the wild, like the mink and the arctic fox, don't have much abnormal behavior in zoos, but species that have big home ranges in the wild, like the polar bear and the lion have lots of stereotypic behavior in zoos. And we see a similar effect of natural behavior as a risk factor for infant mortality in captivity. So again, this is home range size in the wild, and here is infant mortality in captivity, and again we can see species that naturally have small home ranges do well in captivity, species that naturally have big home ranges tend to do bad in captivity. So the polar bear here: two thirds of its babies will die in the first month.

And if we look at the natural biology of a polar bear, we can see what an enormous difference their life in the wild is from their life in captivity. So when polar bears in the arctic travel, a home range may be nearly 80,000 square kilometers, and even an animal with a small home range still moves a thousand square kilometers each year. And this is a big contrast with the typical enclosure size in the zoo, which may be just a thousand meters squares. So the typical enclosure size in the zoo is 1/1,000,000 the size of the home range in the wild. We can see this is a big difference, and maybe no wonder that's why they have welfare problems. So this was an example of species differing in welfare and finding out the reasons why.

So you can see that we can use variation between zoos to start identifying what causes animals' bad welfare. And here is one last example. So this species is the clouded leopard. And another multi-zoo study by Nadja Wielebnowski showed that in zoos that have lots of hiding places that are up high and lots of places where the animals can escape from the public, again these animals have low levels of corticosteroids. But if there aren't places to hide, then the animals have high levels of corticosteroids.

So put together this information showing that wide ranging species tend to have more welfare problems and that animals that can't retreat from humans tend to have more welfare problems, really raises two questions. And the first question is: Do animals miss a natural life? Is not having a natural life a problem? And the second question is: Can we make bad welfare conditions into good welfare conditions by making the environments more natural? And as professor Ueno said, one significant way of doing this is to add objects



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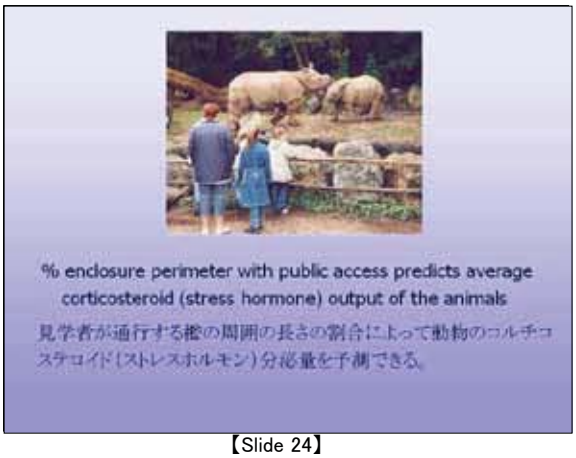

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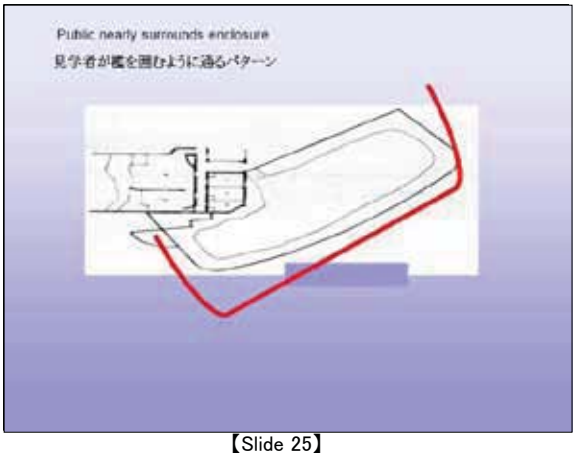

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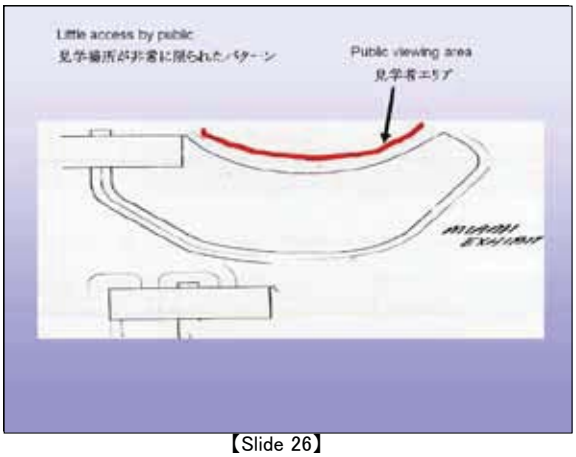

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and structures to interact with in the environment; so to enrich the environments and to give the animals more to do.

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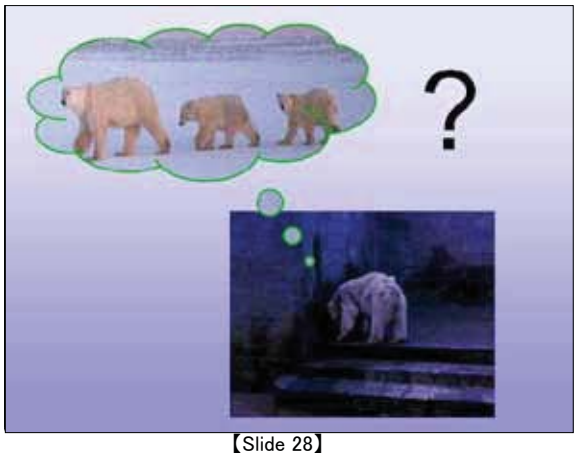

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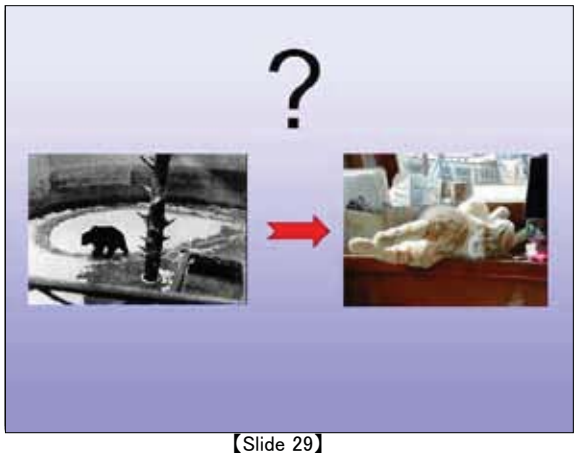

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So what I want to do now is to show you some data that illustrates how important environmental enrichment is for animals in zoos. And I'm going to give you examples from zoos, but also examples from other species as well, just because they've been so well studied. So I showed you this slide just now, and I told you that across different zoos, zoos that have lots of hiding places tend to have more relaxed clouded

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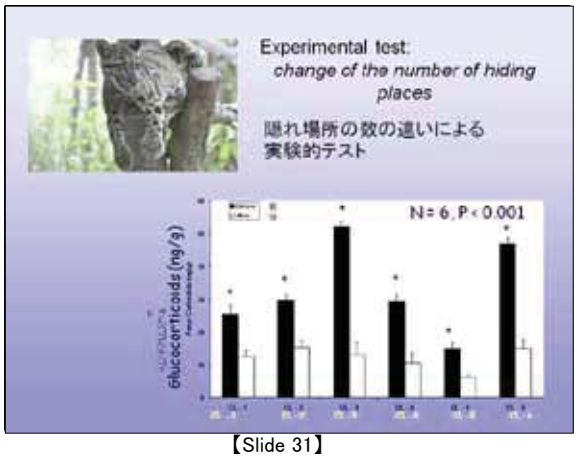

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leopards and zoos that don't have hiding places seem to have more stressed clouded leopards. So this suggests an obvious way of improving the enclosure for this species: give them more hiding places. So does this work? So here is data from an experiment by Nadja Wielebnowski from Brookfield Zoo. And here, each pair of bars is one animal, so there were six clouded leopard here. And what these data show is their levels of stress hormones. The black bars show their stress hormones before they were given enrichments and the white bars show their stress hormones after they were given raised up places in which they could hide. And you can see that in every one of the six clouded leopards in the six different zoos, when they were given hiding places, their stress hormone levels went down; their stress hormone levels more than halved. So that's a nice example looking at stress hormones. What about abnormal behavior?

So here we see the typical stereotypic behavior of a gerbil kept in a laboratory cage. They go to the corner of the cage, and they make these digging, digging, digging movements. So, why do gerbils show stereotypic digging? And, can we stop this behavior

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with environmental enrichment? Well, if you look at what gerbils do in the wild, they live in the desert and they naturally dig burrows. And here, you can just see the little gerbil. Can you see its eye poking out of the hole? So they dig these burrows to escape from the heat of the desert sun and to hide from the cold of the desert night. So having a burrow is very functionally important for them. And what happens is they dig a tunnel, and then it goes to a little nest chamber where they can sleep and raise their babies. So even in a laboratory cage, you give them a nest chamber with a tunnel; it completely stops stereotypic digging. They need a tunnel going to a nest chamber to feel safe. And if they don't have the correct type of nesting chamber, they would carry on doing this stereotypic digging.

And this illustrates something that professor Ueno said earlier. You don't always have to give animals completely natural stimuli. You can give them artificial stimuli that satisfy them in the way that natural stimuli do. And here's another example that illustrate that point too. Horses are naturally social species; they naturally live in herds. And if you keep a horse by itself, isolated in a stable, it will show lots of stereotypic behavior. If it can see other horses, it will show much less of this behavior. And even if you give it a mirror, that will reduce its stereotypic behavior. So this isn't a real natural stimulus, but it tricks the horse into thinking that it has company. And the it feels as though it is in a herd. So this is a very nice example of an environmental enrichment that is artificial, but it mimics an aspect of the natural life.

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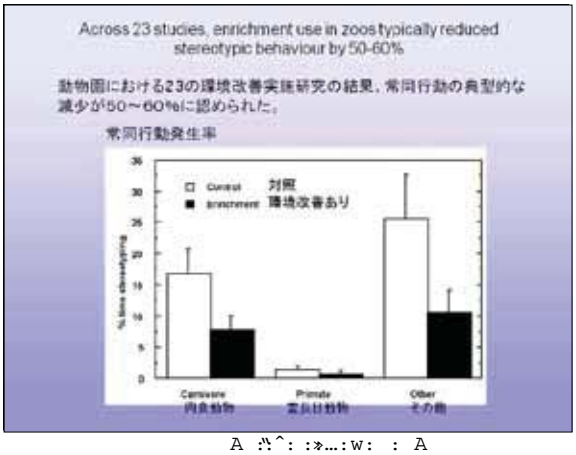

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So does this work in zoos? Well, the answer is most definitely yes. So these data come from a survey of 23 studies that have been done across zoos all over the world. And this data shows that when you give environmental enrichment stereotypic behavior falls; typically, it falls by about 50%. So on the whole, giving enrichments to carnivores, or primates, or to many other species, seems a very successful strategy in zoos.

And enrichment doesn't just reduce stereotypic behavior, it can help other benefits as well. So this is an example of work by Ron Swaisgood and some Chinese collegues working in the Wolong Panda Breeding center in China. And they found, in this breeding center, the pandas were having lots of problems – lots of reproductive problems – and they embarked

on a big strategy of environmental enrichment. They redesigned the enclosures, they gave them objects to interact with, and they made their diets more natural, so they put bamboo in their diet. And they had lots of success; it triggered the birth of many babies – here are some babies here; they look like toys but they're real – and the enrichments also reduced stereotypic behavior. So all these examples from wild animals and also domesticated animals show you that good environmental enrichments prevent or reduce chronic stress in captive animals, and they also reduce abnormal behavior. And they seem to do this by allowing animals to escape from things they find frightening, and that might include us humans, and it also allow animals to meet their behavioral needs –the high motivations to perform natural behaviors that they would do in the wild. Now, we know this, and good zoo keepers know this, and good zoo curators know this.

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What I want to do next, for the last section of my talk, is to talk about things that are a little bit more speculative, but I think that are interesting because they show that enrichment might have some practical uses as well.

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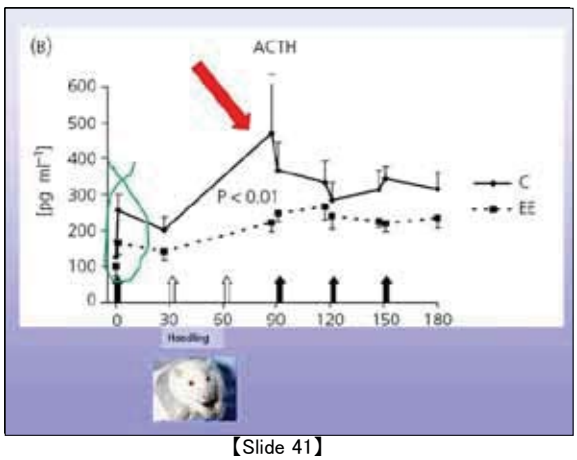

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So even if you don't care about animal welfare, if you want to persuade someone that environmental enrichment is important, you might want to persuade them that it has practical benefits that are worth the time, the energy, and the cost.

So let's look now at some work on laboratory animals that suggest some unexpected practical benefits that environmental enrichments might have. Now we don't know if these work for zoo animals, but my bet would be yes. So the type of work I'm talking about typically looks at laboratory rodents, like this rat, and some of the work looks on mice, and then at the end I'm going to show you some work done by one of my PhD students on mink that we keep as a research subject. Now people at work with rodents look at environmental enrichment of a range or types; so they might keep them in a small boring cage like this, they might add a few enrichments, or they might keep them in a big fancy cage like this full of toys and novel objects.

Now when you keep rats and mice in enriched cages, just as we saw with zoo animals, the environmental enrichments typically reduce stress and reduce abnormal behavior. That's not new. It's nice to see, but it's not new. But what we also see is some other things as well. So first of all, we also see the environmental enrichments improve animals' abilities to cope with stress even when they're taken out of that enriched environment. So it seems to make animals better able to cope, more stress resistant. So I'll give you some examples. And it seems to make them, sorry, I should say it seems to better able to cope with stress and it makes them better able to cope with disease. So they're good at coping with challenge. So in this first example, this is just one example of many showing that laboratory rodents within environmental enrichment are better resistant to acute stress. So in this experiment, rats were kept in big enriched cages or they were kept in small monotonous laboratory cages like these. And the stressor the rats were exposed to was being picked up and handled, which rats typically don't like very much.

So this graph shows stress hormones released by the adrenal glands. That's what these lines are. The dotted line are the data from the animals in the big enriched cages. And the control, or the "c line" is for

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the animals in the small boring cages. Now when there is no challenge, the two groups of animals look the same; these two lines are not significantly different. But when they are exposed to the challenge of being handled, picked up, and grabbed, the control animals show a big release of stress hormones, and the enriched animals don't. They just cope with the stress, they're just not that bothered about it. And there are many, many similar examples. And when it comes to looking at the effects of enrichment on disease resistance again we find lots of examples too. So for example, laboratory rodents are often used to study human diseases. They can be diseases like Huntington's disease, epilepsy, or Alzheimer disease. And in all these research conditions, animals that have environmental enrichment showed less severe forms of the disease. So enrichment reduces Huntington's disease, epilepsy, and Alzheimer disease. It also reduces the risk of getting infectious disease. Animals with enrichments also have better wound healing; so if they are cut, or if they have surgery, they heal faster. And their immune systems are generally better. And some studies even suggest that rodents with enrichment live longer lives. So here's just one last example. If you house a male mice with a nice female, and if he's in research where he's given a stroke – this is not a very nice research, but rodents are used in this research all the time- if he's given a stroke in the head, males that are housed with a female recover much faster from this injury than males that are kept on their own.

In more experiments with mice, mice that have prion-disease, so, like mad cow disease, mice that have the prion-disease stopped making burrows at a very early stage in the disease. So again, their giving up of natural

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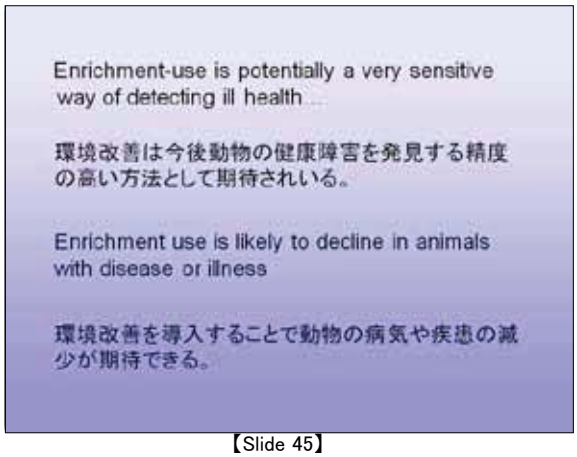

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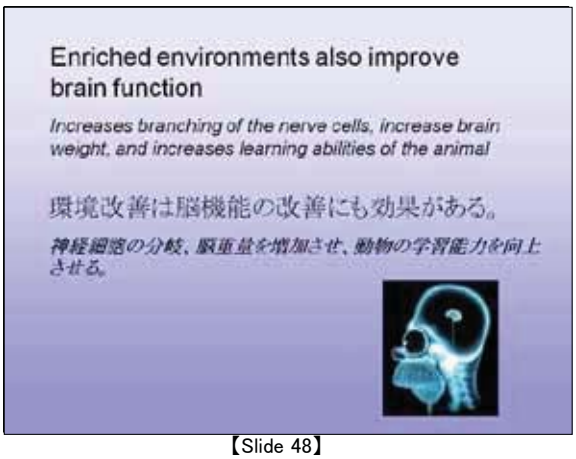
behavior is a very sensitive indicator that something is wrong with them. So this might be very practically useful.



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Another advantage of environmental enrichment that's shown to us on studies on mice and rats is that environmental enrichment improves brain function. It improve the development of the brain and it also improves the animal's ability to learn and to remember. And we can see anatomically many changes in the brain; increased branching in the nerve cells, and even increased brain weight. And so as a result, an animal that is raised in a standard, unenriched environment tends to have a smaller brain that doesn't work so well.

They're basically more stupid, they have less good learning ability.

Now the last example I want to give you comes from a study in my own laboratory, done by a PhD student of mine, Maria Diaz. And we were interested to see whether environmental enrichment makes animals more attractive to members of the opposite sex because one problem we often have with captive animals is that they won't mate with each other. It can be a problem in zoos, it can be a problem all over the place. So we

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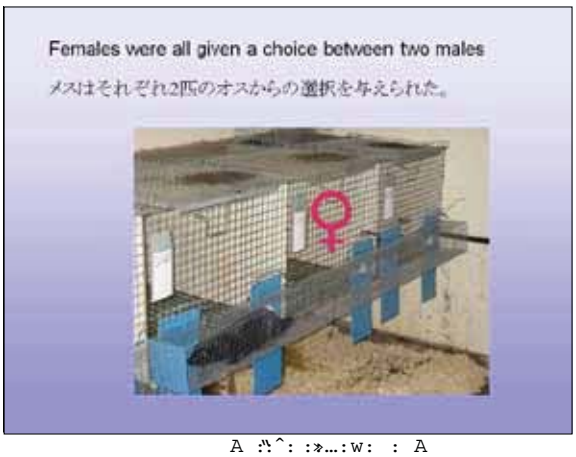

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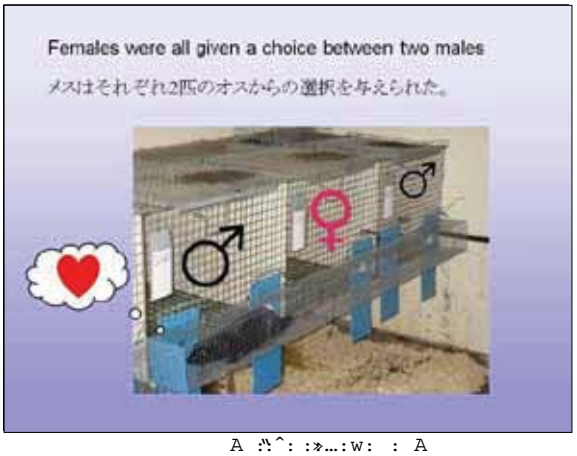

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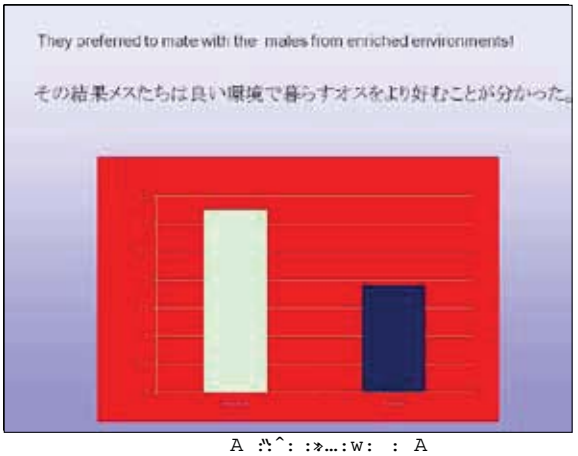

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wondered whether females would prefer to mate with low stress males from enriched environments. Are these males more attractive? Do they may be seem as though they may have better genes and that they would be better father's for a female's offsring? And here we have a female mink, thinking about it. So to do this experiment, we housed mink in two types of environments. In one environment, they were kept in home cages that were small and bare. And you can see here, there's one, two, three, four, five, six, seven small, bare home cages and these are the standard environments. But for half the mink, these home cages had climbing towers coming out of the top of them. And these towers led to wonderful, enriched compartments, and in these enriched compartments, they had toys, novel objects, they had flowing water in which they could swim. They had lots of interesting things to do. So half the mink are lucky; they can escape from this boring cage, and half fun in the enriched cage.

In our experiment, we gave females a choice between the males, raised in each of these two environments. So this is the female cage, and she can leave it and enter this little tunnel, and from this tunnel, if she wants, she can visit a male on either side. There are little holes here that the female can get through if she wants to visit a male. The male is too big, and he can't get out of these holes, so all the male can do is to wait and hope that she will visit him. So here's a female deciding between a standard house male and an enriched house male who has a tower here that connects to enrichments elsewhere. And she's deciding which male she likes best. And we found very convincingly that the females preferred to mate with males from an enriched environment. So here we have the numbers of matings and here we have the enriched males and here we have

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the barren males. So animals that are environmentally enriched are more attractive to the opposite sex.

So all these studies from laboratory rodents suggest not only that environmental enrichments can reduce stereotypic behavior and reduce stress in the home environment, but they can also have benefits out of that environment as well, improving animals' abilities to cope, and maybe having other practical benefits that we haven't yet measured in a zoo situation.

So just to conclude, then for zoo animals we know that environmental enrichment can reduce stereotypic behavior, it can improve infant survival, and it can allow animals to perform natural behaviors. And work on rats, mice, and mink in research laboratories, also suggest that environmental enrichments may well improve abilities to cope with stress and disease, improve animals' cognitive abilities. It may improve humans' abilities to detect illness at a very early stage which would be useful for vets, and it may make animals more attractive as mates to members of their own species.

So that's it. Thank you very much.

Dr: Ueno:

Thank you, Georgia. Does anybody have any questions about this presentation?

Audience:

Thank you very much for your very, very interesting lecture. I suppose, since I'm asking you, I should ask in English; it's might be easier. Reading your abstract, you mentioned something about predators and prey being very close together and that being very stressful. It wasn't in your lecture, but recently we've read that one of the Japanese zoos is planning a polar bear enclosure where the polar bears has access to a glass window to seals. I'd just like to ask your opinion on that. Thank you.

Dr. Mason:

There's good data showing that at least in the felids, small felids, so small cats that are housed near big cats like lions and tigers, have problems with stress; perhaps not surprisingly. So I would think that the seals would have some problems being housed next to the polar bears. The question is, is it good for the polar bears to see the prey? And actually, I'm not sure, because it may be stimulating and wonderful, or it may be very frustrating; like always seeing candies in a candy store that you can't get to. They see these delicious seals and they can never get to. And it's really not very nice for the seals. So my instinct would be that it's not a very good idea.

Audience:

Thank you very much.

Dr. Ueno:

Other questions?

Audience 2:

In experiments, in the case of animals, those with enriched environments, you said were more attractive to the opposite sex. Can the same be said for people?

Dr. Mason:

Is it true for humans? Yes (laugh). Yes particularly, it's terrible to say this, but in human females, females are interested in resources and money more that men are interested in them. So yes. So across all mammals, females are looking for a mate that can provide a good territory, good genes, he's showing resistance to stress, he doesn't have diseases, he's big and strong. So a male that's raised in an enriched environment whose not stressed, and whose not going like this with stereotypic behavior, is probably more attractive. There are nice data from humans, there are nice data from lots of species.

Audience 2:

So could you give me some advice on what kind of environment I should put myself in, in order to attract the opposite sex?

Dr. Mason:

I don't know. You can judge as well as me.

Dr. Ueno:

So maybe one more question?

Audience 3:

I heard lots of interesting things about stereotypic behavior. There is behavior such as pacing, that happens as displacement behavior due to the lack of the ability to engage in other behaviors, and there is behavior that remains as a habit even after the environment is changed. I would like to know if there is a structural difference between the two.

Dr. Mason:

That's a very good question. So, I showed you data, showing that when animals have enrichment behavior drops by half but it doesn't disappear. And to some extent it may fall because some of the behavior changes and just looks less ugly. And I think in cases like that, enrichment either isn't enough or it's given too late and changes have happened in the animal's brain and it's too late then to have a good effect. So for a really successful enrichment it needs to be good enough for the animal and it needs to happen early, at an early stage before it gets too fixed. Does that answer your question?

Dr. Ueno:

There may be more questions, but let's wrap this up for now and move on to the next presentation.

Dr. Ueno:

How do scientists relate with zoos?

Dr. Mason:

Collecting scientific data in zoos is challenging , and I think that's why it maybe does not happen enough. The challenges are, at each zoo there just very few animals. So if you want to collect lots of data, you need to visit multiple zoos, and then that costs money. And sometimes if you're lucky a scientific funding agency would pay, but if that isn't the way things operate here, and I don't know, then the zoos have to pay. And then the question is, do the zoos want to pay to find out that some of their animals are stressed? And that's the problem. But I think you're right; I think it's important husbandry must be objective, it must be based on evidence, or the same mistakes get ignored over and over again and they happen over and over again. Most of the problems with zoo animals are solvable, but they're solvable by looking at things objectively. And for that I think you're right; you need data. And that's all I can say. I agree.

Dr. Ueno:

What do you think of visibility of animals in zoos.

Dr. Mason:

Umm, it's difficult for me to comment, but I guess I'd say, when animals don't want to be seen we must respect that. When animals want to be seen, it's fantastic and of course that's why we go to the zoo. But if they don't want to be seen, I think we mustn't force them. So maybe we have to educate the public. Well, the animal wants its privacy now, so sorry, just move to the next enclosure. Or we have to pick our species with care. Some species just do fantastically and don't mind. And other species are very sensitive. So maybe that's the solution. So I don't know if that's a good answer, but it's the best that I can think of.

Yes, you just gave me the exact answer I was looking for. Thank you.

Audience 4:

Are the zoos in your country private, or public?

Dr. Mason:

Well, I have two countries because I am English and I live in Canada. So in Great Britain, the zoos are a mixture of privates and some owned by the city. And I'm less sure about Canada, because I don't really understand the country yet, but most zoos are operated as businesses as though they are private enterprises.

Audience 4:

So do you think that's the main reason that there are such differences between the two countries? England and Japan.

Dr. Mason:

I honestly don't know because that's such a complex question. And it's questions about how people perceive animals, why people go to the zoos. I mean that's a deep question. I don't think it's just structural, I think it's cultural.

Audience 4:

So you think it's not that simple. Okay, I got it. Thank you.