Fishing for Answers off Fukushima

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many cases, the Cp moiety is an attractive candidate for chiral induction because it is often the only ligand that remains bound to the metal throughout the catalytic cycle.

Ye and Cramer synthesized an elegant chiral C_2-symmetric Cp ligand and then applied it in asymmetric catalysis with a rhodium catalyst system of the type [(η^5-C_5H_5)$RhL^1L^2L^3$)] (see the figure, panel B), where the Cp ligand should selectively determine the spatial arrangement of the other three ligands—L^1, L^2, and L^3—around the metal. To achieve the required selectivity, three ligand features were critical. First, a C_2-symmetric ligand (one that is chiral and has only one 180° rotational symmetry axis) avoided the formation of two isomeric complexes derived from incomplete "facial selectivity" with respect to the coordination of ligand to the metal (that is, which side or "face" of the Cp-derived ligand binds). Second, steric bulk next to the Cp ring restricted rotation around the Cp moiety and allowed for a single preferential alignment of substrates. Third, shielding from a remote substituent on the ligand directed the approach of the incoming reactant to the opposite side.

The Cp*Rh(III)-catalyzed annulation of a benzohydroxamic acid derivative and alkenes, recently independently developed by Fagnou, Glorius, and their co-workers (*8*, *9*), offered an excellent opportunity to test the concept of chiral Cp ligands because of its mild and simple reaction conditions (*10*). Indeed, a rhodium precatalyst equipped with a carefully modified Cp ligand allowed Ye and Cramer to obtain dihydroisoquinolones in high yields and enantiomeric ratios (er's) up to 97:3. The Rh(III) catalyst generated in situ by oxidation was proposed to be the active catalyst. The reaction scope is quite general with high yields and er's, suggesting that the catalyst system is robust.

The biological approach taken by Hyster *et al*. functionalized Cp with biotin so that biotin-protein interactions would drive the incorporation of the Cp-metal complex (which continues to act as a catalyst) within a protein scaffold to form an artificial metalloenzyme (which creates a chiral environment) (*11*) (see the figure, panel C). The introduction of an appropriately positioned functional group within the protein should further facilitate the reaction. They also used the Cp*Rh(III)-catalyzed synthesis of dihydroisoquinolones as a test reaction (*8*, *9*). A biotinylated Rh(III) complex $[RhCp^{*biotin}Cl_2]_2$ was designed and incorporated within wild-type streptavidin.

Initially, the substrate conversion was disappointingly low. Noting that the presence of a basic residue in appropriate proximity to the metal center should help facilitate C–H activation (*12*), Hyster *et al*. created an artificial metallodyad by introducing a basic carboxylate residue within the protein through computational modeling and genetic engineering. An extensive survey of mutated streptavidin showed that a double mutant (Ser^{112} to Tyr and Lys^{121} to Glu) gave the desired product in excellent yield, with good regioselectivity and, most important, up to an enantiomeric ratio of 93:7. Only a few examples were demonstrated, indicating a limited substrate scope, but considering the high specificity of natural biocatalysis, this result is exciting and encouraging. It represents a rare case of an artificial metalloenzyme inducing high levels of both selectivity and reactivity.

Chiral Cp ligands bearing one or more additional coordination groups have already been successfully used together with early transition metals in asymmetric catalysis (*13*). In contrast, the application of these Cp derivatives to middle or late transition metal catalysis is intrinsically problematic because too many coordination sites of the metal are occupied. Considering that middle or late transition metal complexes are arguably more synthetically useful, and Cp is frequently responsible for their stability and reactivity, the successful design of chiral Cp derivatives will offer tremendous opportunities for late transition metal asymmetric catalysis.

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ECOLOGY

Fishing for Answers off Fukushima

Ken O. Buesseler

Radionuclide levels in fish off Fukushima are highly variable but remain elevated, indicating a continuing source of radiation.

The triple disaster of the 11 March 2011 earthquake, tsunami, and subsequent radiation releases at Fukushima Dai-ichi were, and continue to be, unprecedented events for the ocean and for society. More than 80% of the radioactivity from Fukushima was either blown offshore or directly discharged into the ocean from waters used to cool the nuclear power plants (*1*). Although offshore waters are safe with respect to international standards for radionuclides in the ocean (*2*), the nuclear power plants continue to leak radioactive contaminants into the ocean (*3*); many near-shore fisheries remain closed. What are the prospects for recovery?

Public anxieties in Japan about seafood safety remain high, in part because the Japanese are among the world's highest per capita consumers of seafood. On 1 April 2012, regulators tightened restrictions for cesium-134 and cesium-137 in seafood from 500 to 100 becquerels per kilogram wet weight (Bq/kg wet) in an effort to bolster confidence in the domestic supply. In fact, this measure may have had the opposite effect, as the public now sees more products considered unfit for human consumption.

The Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF) has been monitoring radionuclides in fish and other seafood products since 23 March 2011. They have been releasing these data on a regular basis, most notably in a single annual compilation of more than 8500 samples of fish, shellfish, and seaweeds collected at major landing ports and inland freshwater sites, particularly in the most affected coastal areas near Fukushima (*4*).

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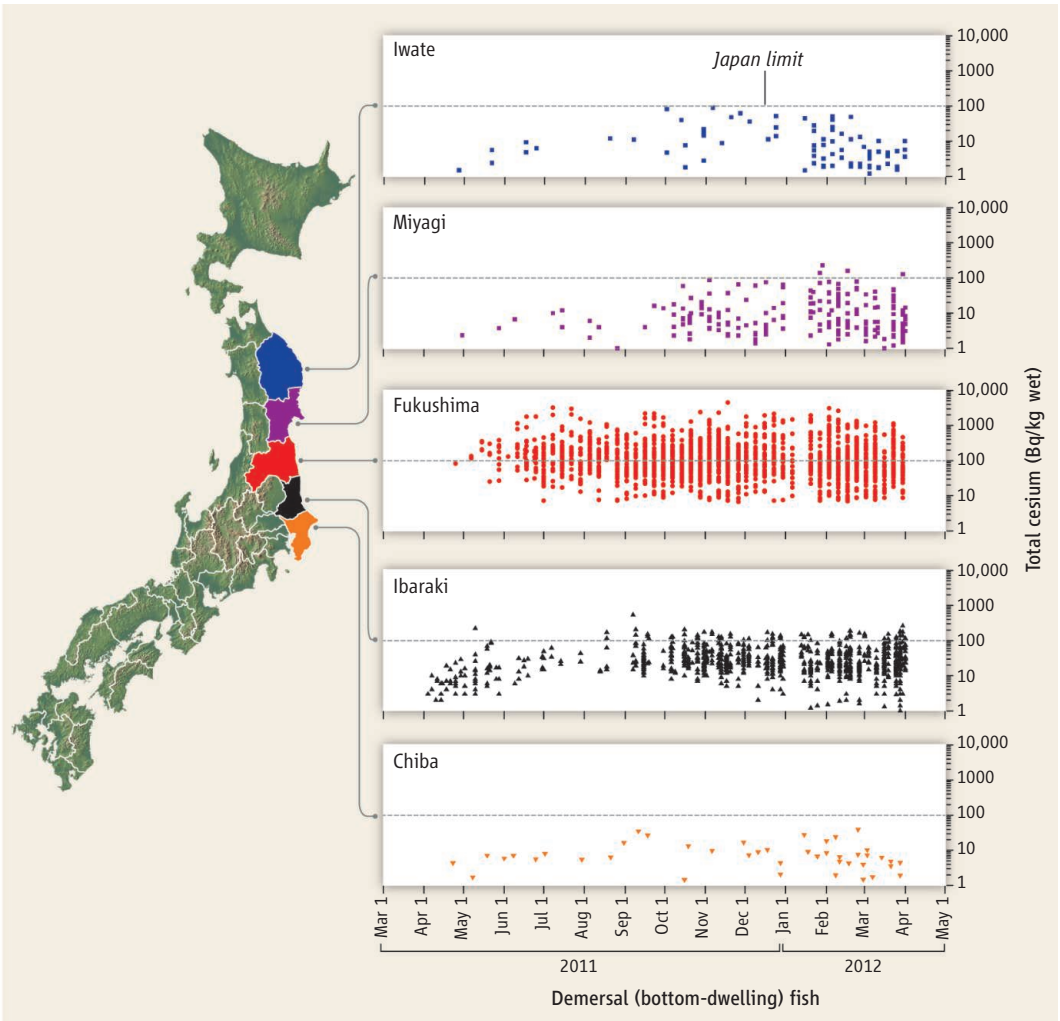

Still radioactive. Changes in total cesium (^{137}Cs + ^{134}Cs in Bq/kg wet) over time in demersal (bottom-dwelling) fish for five prefectures in eastern Japan closest to Fukushima. Since the nuclear disaster, total cesium levels have been highest in fish caught off Fukushima prefecture.

The MAFF results show that total cesium levels in demersal (bottom-dwelling) fish, including many important commercial species, are highest off Fukushima and lower in four prefectures to the north and south (see the figure). Fishing for these species is currently banned off Fukushima, where 40% of fish are above the new regulatory limit of 100 Bq/kg wet (*4*).

Demersal fish have higher cesium levels than other marine fish types, grouped here as epipelagic (near-surface), pelagic (open ocean), and neuston (surface-dwelling) fish. Contamination levels of demersal fish are comparable only to those of freshwater fish (see fig. S1). Cesium levels have not decreased 1 year after the accident, except perhaps in neuston, and as of August 2012, fish are still being found with cesium levels above 100 Bq/kg wet (*5*). The highest total cesium levels found to date, more than 25,000 Bq/kg wet, are from two greenling caught in August 2012 closer to shore off Fukushima (*6*).

Cesium accumulates in fish muscle tissues with relatively modest concentration factors; the Cs concentration in fish is typically 100 times that in the surrounding seawater (*7*). The concentration factors increase only slightly as one moves up the food chain (*8*). Bioaccumulation is much higher in general in freshwater fish because of lower salinities (*9*) (see fig. S1). Uptake of cesium is balanced by loss back to the ocean, which increases with body size and metabolic rate (*8*). The loss rate is a few percent per day on average and has been shown to be faster if the cesium supply is pulsed rather than steady (*10*).

Given these high loss rates and the fact that cesium-134 and cesium-137 remain elevated in fish, particularly in bottom-dwelling species, there must be a continued source of cesium contamination associated with the seafloor. Reports of Fukushima cesium in marine sediments, although not extensive, support the assumption that the seafloor is a possible source of continued contamination (*11*). Given the 30-year half-life of ^{137}Cs, this means that even if these sources were to be shut off completely, the sediments would remain contaminated for decades to come.

The variability in total cesium levels for any given date and fish type is extremely high, making management decisions of when to open or close a particular fishery more difficult. The wide range of observed cesium levels may be due to variability in the cesium loss rates from fish, the life stages of each species, and differences in habitat. Of course, many fish move over wide spatial scales, which will also affect cesium levels in fish caught at a particular location that may have been exposed elsewhere.

The MAFF data show that the vast majority of fish remain below even the new, stricter regulatory limit for seafood consumption. Many naturally occurring radionuclides appear in fish at similar or higher levels and are not considered a health threat. For example, in fish sampled in June 2011 off Japan, natural levels of potassium-40, a naturally occurring beta emitter like cesium, were more than 10 times those of Fukushima-derived cesium (*2*). Moreover, because cesium is rapidly lost from muscle after exposure stops, fish that migrate to less affected waters will gradually lose much of their Fukushima-derived cesium, as seen in a report of tuna caught off San Diego (*12*).

Nonetheless, the fact that many fish are just as contaminated today with ^{134}Cs and ^{137}Cs as they were more than 1 year ago implies that cesium is still being released to the food chain. The Japanese government is using the MAFF results to keep fisheries closed off Fukushima and to closely monitor neighboring areas where levels are approaching the regulatory limits.

Knowledge of the patterns of radionuclide contamination and trends over time for different fish types helps to put risks arising from the released radioactivity in context. However, studies of cesium in fish are not enough. An understanding of sources and sinks of

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cesium and other radionuclides is needed to predict long-term trends in fish and other seafood. Such knowledge would support smarter and better targeted decision-making, reduce public concern about seafood, and potentially help to revive local fisheries safely, with confidence, and in a timely manner.

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Supplementary Materials

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Fig. S1
Reference

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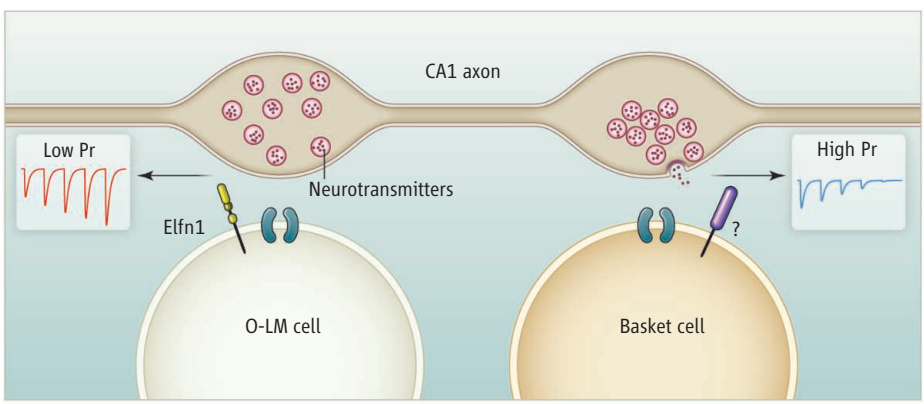
NEUROSCIENCE

Decoding the Neuronal Tower of Babel

Identification of a postsynaptic protein in the hippocampus reveals how neurotransmitter release from one neuron is tailored to different target cells.

Chris J. McBain

Individual neurons in the mammalian central nervous system communicate with their downstream targets by means of subcellular specializations in their axon. Arranged like pearls on a necklace, these presynaptic terminals enable the rapid release of neurotransmitter in response to an electrical action-potential wave front that travels from the cell body to the far reaches of the axon. A single axon may contact hundreds of downstream targets, including numerous distinct cell types. Though separated by only a few micrometers, each of these presynaptic release sites is often tuned to the particular cell type it innervates such that transmission may be robust onto one particular cell type yet weak at another, despite all terminals sensing the same action-potential waveform (*1*). This arrangement allows different terminals in the axon to behave independently and "translate" presynaptic action potentials into their own unique chemical language to effect both short- and long-term synaptic transmission and plasticity (*2*, *3*). Whether elements in the presynaptic terminal, postsynaptic membrane, or transynaptic proteins dictate this differential synaptic processing has been unclear. On page 536 in this issue, Sylwestrak and Ghosh (*4*) show that postsynaptic expression of the extracellular leucine-rich repeat fibronectin-containing 1 (Elfn1) plays an important role in establishing such target-specific differential transmission.



Tailoring one neuron to two synapses. In the hippocampus, somatostatin-containing O-LM and parvalbumin-containing basket cells receive common afferent input from CA1 pyramidal neurons. The postsynaptic expression of the leucine-rich repeat protein Elfn1 in O-LM cells acts to set the presynaptic initial transmitter release probability (Pr) low, ensuring short-term facilitation of synaptic transmission. In contrast, the absence of Elfn1, of the presence of an as yet undiscovered trans-synaptic protein, endows CA1 pyramidal neuron synapses onto basket cells with a high initial release probability, depressing synaptic transmission.

CA1 pyramidal neurons of the hippocampus form synapses with many downstream inhibitory interneuron targets, including the parvalbumin-containing fast-spiking basket cell and the somatostatin-positive oriens-lacunosum moleculare (O-LM) neuron. Under normal conditions, a train of presynaptic action potentials in the CA1 pyramidal neurons triggers robust synaptic transmission onto basket cells (such synapses are referred to as having a high initial release probability), such that larger synaptic events are triggered early in the train, which then rapidly wane as the train progresses (i.e., short-term depression). In contrast, synaptic events onto O-LM cells start small and grow as the train of action potentials progresses (a process termed short-term facilitation, and indicative of synapses with a low initial transmitter release probability). Sylwestrak and Ghosh demonstrate that Elfn1 is selectively expressed in O-LM inhibitory interneurons and that its punctate expression on dendrites reveals a strong enrichment at synapses where the neurotransmitter glutamate but not the neurotransmitter γ-aminobutyric acid is released. Targeted elimination of

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