**[A magnetic protein biocompass]**

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**Key Words:**

Stem cell, transcription factors, mesenchymal, stem cell therapy

**[Abstract here.] As we all know ,some animals can detect the magnetic field and perceive cues from geomagnetic fields to navigate and migrate over the long distance.The reason was once unknown,but is well explained now.This review is intended to introduce the methods and thoughts in constructing such a magnetic protein biocompass,which can inspire deeper study in the magnetic protein and innovation in different technology.**

**Introduction**

[ The sense in detecting the Earth’s magnetic field is one of the most controversial senses.We already find that many species utilize the ability to sense the magnetic field to guide their direction during a long distance migration.In ancient China ,people used pigeons to transport messages because of their ability to go back to their home from a long distance .For people ,we believe the geomagnetic field can affect the light sensitivity of the human visual system .The study to identify a magnetic receptor and understanding the mechanism of animals sensing the magnetic filed will inspire the development in science and technology.

 There are several models proposed to explain the nature of the magnetoreception(the ability to detect the Earth’s magnetic field).Schulten first built the model of chemical compass ,later others developed several different models.According to the literature”Cryptochromes(Cry),a class of flavoprotein closely to photolyases,remain the best biochemical magnetoreceptor candidates and have been reported to perceive geomagnetic information via the quantum spin dynamics of a radical-pair reaction initiated by light”However ,Cry can’t formthe basis of a polarity compass ,it need to cooperate with another partner protein.

 Thus ,the scientist in China identified a candidate protein MagR,which can form a rod-like complex with Cry.]

**Recent Progress**

 [ The profession adopted a different strategy from the traditional approaches.They combine theoretical,genome-wide screening,computational modeling and experimental validation to describe the basic theory of the animals sensing.

 First they select the candidate proteins according to the principals they believe in.

1. The protein has interaction with the Cry and functions as a magnetoreceptor.

(2)The protein can form linear polymerization to sense the weak magnetic filed and the inclination.

(3)Due to the interaction between MagR and Cry ,their complex can absorb light and sense the magnetic field.

(4)The nanoscale magnetosensor may have an intrinsic magnetic moment.

 From the fruit-fly genome assembly(BDGP5),there are 199 iron-binding proteins,132 of them are abundant in the head(including brain and eyes),for the hypothesis that the complex can absorb light.After using all the hypothesis,the candidate proteins are reduced to 14 for tests.Then they find that only one protein,CG8198 ,can from a stable complex with dCry.They rename CG8198 as dMagR,and try to find the functional complex formed by Cry and MagR.

 They use size-exclusion chromatography to confirm the stable protein interaction between MagR and Cry.The fluorescence emission spectrum indicated the presence of FAD and the binding of iron.EM was used to determined the stucture of the complex.The rod-like particles is in the major populations,and there are also two classes of particles with disk-like shapes.But they maybe the same particles from different views.

 After determining the structure in EM ,they tried to build a 3D homology model to interpret the complex at the molecular level.The 3D model of pigeon clMagR was generated based on the structure of the homologous bacteria iron-sulphur cluster protein IscA(PDB ID:1R94).Its metal irons located at the centre in a double-helical linear polymerization.What’s more ,from the top view ,the rod-like model’s pattern is disk-like.Then they modeled the core structure according to the crystal packing pattern of the IscA.

 Biochemical and mutagenesis studies confirm the structure of the complex.Deleting the conserved C-terminal helix of Cry decreased the complex formation.Removing the Fe-S cluster in MagR nearly broke the complex. A interesting discovery that the two conserved helices of MagR,appear on the surface and arrayed as a ladder in the MagR polymer,which means Cry may slide along a ladder on the surface of the rod-like polymer.

 Finally they tested the existence of an intrinsic moment of the Cry/MagR complex.EM imaging a simple purification procedure of the MagR and MagR/Cry complex with iron beads,protein crystallization experiment ,directly measuring the magnetic properties of the protein complex in solution.In conclusion ,the professor announced that “To our knowledge, this is the first time that a protein or protein complex has been shown to possess an in intrinsic magnetic moment and biocompass-like functionality”For the intrinsic moment ,they proposed two possible reasons:the linear array of the iron atoms or a synchronized circular current in the iron loops

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**Discussion**

[ The study shows us that the specific Fe-S cluster protein in animals interacts with the known magnetoreception-related protein cryptochrome and forms a nanoscale complex,which has the potential to act as a biocompass.The unique structure of rod-like may suggest a mechanism for the coupling of light and magnetosensing.

 But there are still more questions we can’t solvenow.We can’t prove the mechanism of the coupling of light and magnetosening.We have no idea how the information is transported to the neural system.The way to from our magnetic sense is still mystery,but with the pioneered work to find such a protein we may promote others to study theses questions.

 This review is mostly based on one paper ,so I put my point on introducing the hypothesis of the author to select the protein and the method to identify the Cry/ MagR complex.It’s impressed that the professor can begin the work from some hypothesis based on basic physics principals.And then he identify them with experiments.There is doubt that this research can promote the study of animals behavior and senses into molecule level.It also can attract more works to understand the formation and transport of the magnetic information. ]

**References**

[A magnetic protein biocompass Nature materials DOL:10.1038/NMAT4484,2015]