沈允钢先生与上海师范大学的光合作用研究

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30年前, 我在南京大学为考研究生埋头苦读。当时班级里有一位同学被推荐到中国科学院上海植物生理研究所(植生所)师从沈允钢先生攻读硕士学位。从同学和老师那里了解到植生所是我们继续深造最理想的研究所。那时, 本科专业设置与现在不同, 南京大学的生物系(相当于现在的生命科学学院)有4个专业, 分别为植物学、动物学、动物生理以及生物化学; 我们所在的植物学专业到了本科三年级又进一步分为高等植物、低等植物和植物生理学三个方向。受直研同学的影响, 我们学植物生理的同学有多人报考植生所。南京虽然离上海不远, 但没有现在的网络信息, 我们从《植物生理学通讯》(现改名为《植物生理学报》)那里了解植生所的情况、各自报考导师的研究方向, 以及中国植物生理学的开创和发展。经过努力, 我们班又有3位同学考入植生所, 我也有幸考入许智宏先生门下攻读硕士学位。当时沈先生是植生所所长, 作为植生所的在读研究生, 经常见到沈先生忙碌的身影。在植生所读研究生期间, 沈先生所领导的光合作用研究室位于当时4号楼的5~6层, 是所里实力最强的研究团队之一。我当时在4层学习, 有了更多机会了解光合作用, 认识到其不仅在植物科学, 在其他多个学科中也都具有重要的意义。

我从植生所毕业后到国外进行博士后研究, 于2002年回国到上海师范大学工作。在筛选模式植物拟南芥突变体时, 发现白化突变体是最容易筛选到的突变体。白化突变体主要是叶绿体功能异常导致, 可能与光合作用密切相关。回想在植生所读书期间, 了解到光合作用的重要性。当时国内对拟南芥白化突变体的研究较少, 于是我立足于上海师范大学, 对白化突变体开展系统的研究。当沈先生了解到我在上海师范大学也开展光合作用的相关研究时, 给予了我大力的支持。有一次到所里碰到沈先生, 先生非常热情请我吃饭。为了进一步了解我课题组关于叶绿体方面的工作, 还让我写了研究计划和思路交给他。当他了解到上海师范大学生物学没有博士点时, 特地以他的名义招了一位直博生由我来培养, 支持我的研究工作。每念及此, 心中充满无限感激。经过十多年的研究, 我的团队以模式植物拟南芥白化突变体为主要研究材料, 在叶绿体基因表达调控和叶绿体发育方面做出一定的成绩。

叶绿体/质体具有自身基因组, 由细胞核编码的RNA聚合酶(nuclear-encoded RNA polymerase, NEP)和质体编码的RNA聚合酶(plastid-encoded RNA polymerase, PEP)负责转录。两类聚合酶中, NEP负责PEP最重要的亚基rpoA多顺反子的转录。我们的结果揭示, 核编码的PPR蛋白PDM1在*rpoA*多顺反子切割成*rpoA*转录本过程中起关键作用(Wu和Zhang 2010; Yin等2012)。此外, PDM1还与质体编辑关键蛋白MORF相互作用参与多个质体基因的编辑(Zhang等2015)。PEP是叶绿体主要的聚合酶, 由5个核心亚基组成, 分别为rpoA 2个, RpoB、RpoC1和RpoC2各1个。PEP核心亚基和40多个核编码蛋白组成PEP复合物或TAC (transcriptionally active chromosome)复合物(Yu等2014a)。PEP复合物中与核心亚基紧密结合的蛋白又称为PAP (polymerase-associated protein)。我们分析了PEP复合物中pTAC7 (Yu等2013)、FLN2 (Huang等2013)、pTAC14/PAP7 (Gao等2011)蛋白对质体基因表达的作用, 其中pTAC14/PAP7可能参与光调控质体基因表达的作用。拟南芥具有硫氧还结构域的ECB1蛋白虽然不存在于PEP复合物, 但是能与PEP复合物中的TRXz和FSD3互作。该蛋白可能在氧化还原信号通路调控质体基因表达中起作用(Yu等2014b)。叶绿体存在丰富的基因转录后加工过程, 包括RNA剪接、编辑和切割。PPR蛋白

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ECB2不仅是PEP转录所必需的蛋白, 也参与多个质体基因的编辑, 提示叶绿体中基因的转录和转录后加工是两个非常紧密偶联的过程(Yu等2009)。叶绿体发育过程中, 基质片层进一步垛叠成基粒类囊体。对具有锚定结构域的GDC蛋白功能分析显示, LHCII三聚体在基质片层垛叠成基粒类囊体过程中起关键作用, 而GDC在LHCII三聚体形成中起重要作用(Cui等2011)。叶绿体基因表达也与叶绿体发育密切相关。ECB2的等位突变体*ecb2-2*以及*fln2*中质体基因表达下降, 幼苗期植株黄化, 随生长时间延长逐渐转绿(Huang等2015; Cao等2011), 揭示质体基因转录活性的下降导致植物转绿滞后, 即黄化的表型。

沈先生长期关心我校马为民教授课题组的发展。马为民师从沈先生攻读博士学位, 毕业后到上海师范大学工作。当马为民作为一名新教师给上海师范大学奉贤校区本科生上《植物生理学》课程时, 沈先生曾前往奉贤校区进行随堂听课, 并给予指导。马为民在上海师范大学徐汇校区组建藻类光合作用实验室时, 沈先生经常来实验室进行现场指导。在沈先生的长期关心与支持下, 马为民课题组围绕蓝藻光合作用电子传递体NDH-1做出了具有国际影响力的工作。蓝藻NDH-1位于类囊体膜上, 参与光合作用的多个过程, 包括围绕光系统I的环式电子传递和CO_2吸收(Ogawa 1991; Mi等1992), 在蓝藻生理活动甚至生存过程中扮演着至关重要的角色(Pieulle等2000)。马为民课题组首次发现蓝藻NDH-1的电子输入模块, 并证明其接受来自铁氧还蛋白的电子(Battchikova等2011; Gao等2016); 发现了多个稳定蓝藻NDH-1的结构亚基(Zhang等2014; Zhao等2014, 2015); 开辟了蓝藻NDH-1生物发生研究的新方向, 并构建了组装模型(Dai等2013; Wang等2016)。

植物科学的研究周期较长, 在没有博士点的地方师范院校做一些有显示度的工作难度较大。经过十多年的发展, 上海师范大学植物学科有了一定的研究基础。为了进一步提升研究水平, 我们将光合作用作为上海师范大学植物学科重点发展的研究领域。为此, 从中国科学院植物研究所引进了国家优秀青年基因获得者彭连伟博士, 他的研究领域是光合电子传递调控(Peng等2006, 2008, 2009, 2010, 2011; Peng和Shikanai 2011); 从德国慕尼黑大学引进了孙旭武博士作为我校的东方学者, 他的研究领域是叶绿体反向信号的研究(Sun等2007, 2010a, 2010b, 2011, 2016)。感谢沈先生对我们的长期支持, 也希望上海师范大学能为国内光合作用研究作出贡献。

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