the basis of this concept, Coates and coworkers have devised catalysts that can select different sequences of lactide (a cyclic dimer of lactic acid) stereoisomers to create a variety of regular structures, including R-S-R-S (syndiotactic), R-R-S-S-R-R (disyndiotactic), and R-R-R-R-S-S-S-S (stereoblock) (*11*). This novel strategy enables the creation of new architectures from chiral monomers.

The control of stereochemistry and the controlled introduction of functional groups are of paramount importance for the synthesis of pharmaceutical and agrochemical intermediates. Combining these properties in one catalyst remains one of the central challenges in polymerization catalysis. Olefin polymerization catalysts have high stereoselectivities but are notoriously intolerant of functional groups. Recent advances in generating catalysts with higher functional group tolerance have been made with late transition metals (*12*). These catalysts activate olefins in polar and in some cases aqueous media, but few are also highly stereoselective. Promising examples of catalysts that combine stereoselectivity with high functional group tolerance include chiral catalysts for stereoselective metathesis reactions (*13*, *14*), stereoselective palladium catalysts for the synthesis of stereoregular, chiral polyketones (*8*), and stereoselective zirconium and lanthanide catalysts for acrylate polymerizations (*15*).

The control of polymer chain length is also critical in polymer synthesis. Major advances have been made in the development of living polymerization strategies (so called because the catalyst or polymerization initiator remains active at the end of the growing polymer chain). These strategies permit control of the molecular weight and molecular weight distributions and allow for the synthesis of block copolymers. Few systems are both living and stereoselective (*16*, *17*), however, and simultaneous control of molecular weight and relative stereochemistry remains an important goal in polymerization catalysis.

The pace of development in stereoselective catalysis for both fine chemical and polymer synthesis has been breathtaking, but formidable challenges remain. For the next generation of synthetic macromolecules with ever more closely defined properties and functions to become a reality, stereoselective and living cationic or radical polymerization schemes must be developed, highly functionalized olefin copolymers must be synthesized, and new polymer architectures must incorporate defined sequences of monomer units, functional groups, and stereocenters.

References and Notes

1. The 2001 Nobel Prize in Chemistry was awarded to Knowles, Sharpless, and Noyori for their contributions to stereoselective catalysis (see www.nobel.se/chemistry/laureates/2001/).
2. L. Resconi, L. Cavallo, A. Fait, F. Piemontesi, *Chem. Rev.* **100**, 1253 (2000).
3. J. A. Ewen *et al.*, *J. Am. Chem. Soc.* **110**, 6255 (1988).
4. M. Nele *et al.*, *Macromolecules* **34**, 3830 (2001).
5. J. C. W. Chien *et al.*, *J. Am. Chem. Soc.* **113**, 8569 (1991) .
6. G. W. Coates, R. M. Waymouth, *Science* **267**, 217 (1995).
7. O. Kuhl *et al.*, *J. Organomet. Chem.* **604**, 116 (2000).
8. K. Nozaki *et al.*, *J. Am. Chem. Soc.* **119**, 12779 (1997).
9. W. Fan, M. LeClerc, R. M. Waymouth, *J. Am. Chem. Soc.* **123**, 9555 (2001).
10. E. Vedejs, E. Rozners, *J. Am. Chem. Soc.* **123**, 2428 (2001).
11. B. M. Chamberlain *et al.*, *J. Am. Chem. Soc.* **123**, 3229 (2001).
12. S. D. Ittel, L. K. Johnson, M. Brookhart, *Chem. Rev.* **100**, 1169 (2000).
13. A. H. Hoveyda, R. R. Schrock, *Chem. Eur. J.* **7**, 945 (2001).
14. T. J. Seiders, D. W. Ward, R. H. Grubbs, *Org. Lett.* **3**, 3225 (2001).
15. H. Nguyen *et al.*, *Macromolecules* **33**, 1508 (2000).
16. K. C. Jayaratne, R. J. Keaton, D. A. Henningsen, L. R. Sita, *J. Am. Chem. Soc.* **122**, 10490 (2000).
17. J. Tian, P. D. Hustad, G. W. Coates, *J. Am. Chem. Soc.* **123**, 5134 (2001).

PERSPECTIVES: ECOLOGY

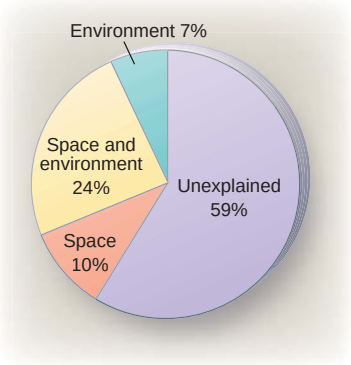
Beta Diversity in Tropical Forests

J. F. Duivenvoorden, J.-C. Svenning, S. J. Wright

The tropics support more than 200,000 species of flowering plants including many tree species (*1*). Yet even between different geographical areas, species composition may vary dramatically. For the tropical forests of Africa, Asia, and the Americas greater than 10^6 km^2 in size, overall or gamma diversity varies from perhaps 30,000 to 120,000 species of flowering plants (*2*). It is well established that smaller forest plots ranging from 0.001 to 0.01 km^2 in area contain from 30 to 300 tree species (alpha diversity) (*3*). Less information is available for beta diversity, which describes how species composition varies from one area to another. On page 666 of this issue, Condit *et al*. (*4*) present a new analysis of beta diversity in which they compare the species composition of forest plots that are located at distances of 10^{-1} to 10^3 km apart in the neotropics of Panama (southern Mesoamerica) and in Ecuador and Peru (western Amazon).

Condit *et al*. explore how similarity in tree species composition from plot to plot declines as the distance between the plots increases. Regions in Panama and the western Amazon that are 10^4 km^2 in area support 3500 to 5000 tree and shrub species (*5*). Yet at smaller scales (10^{-2} km^2), the western Amazonian forests support 2 to 10 times as many species as do the Panamanian forests (*6*). It is possible to obtain rough values for beta diversity from the quotient of gamma and alpha diversity. This method predicts a relatively low beta diversity for the western Amazon, which Condit *et al*. confirm. However, this prediction is not in line with earlier views of strong beta diversity in western Amazonian forests (*6*). The higher beta diversity in Panama presumably reflects greater spatial variation in geology and climate and a lag in forest recovery after the marked temporal variations in climate during the last glacial cycle.

The investigators (*4*) compared their observations to predictions derived from a neutral model that takes into account dispersal capacity but ignores environmental and historical events controlling species distribution. Their data compare well with the neutral model at intermediate distances (0.2 to 50 km) between plots, underscoring the potential importance of dispersal as a key process in the structuring of tropical forest diversity (*7*). At smaller distances, they observed much greater similarity in species composition



Tropical forest diversity. Variance in tree species similarity among plots in Panamanian tropical forests. Distance and environment explain minor portions of the variation in species similarity. The bulk of the variation remains unexplained.

J. F. Duivenvoorden is at the Institute for Biodiversity and Ecosystem Dynamics, Universiteit van Amsterdam, Post Office Box 94766, 1090 GT Amsterdam, Netherlands. E-mail: duivenvoorden@science.uva.nl J.-C. Svenning and S. J. Wright are at the Smithsonian Tropical Research Institute, Apartado 2072, Balboa, Ancon, Panamá. E-mail: svenning@biology.au.dk, wrightj@tivoli.si.edu

between plots than that predicted from the model (*8*). When the distances between plots were much larger as found in the western Amazon, the model again underestimated the similarity in species composition. Condit *et al*. conclude that dispersal is not the principal event that determines the diversity of tree species in western Amazonia (*9*).

To quantify the relative importance of spatial and environmental events in determining species similarity between plots, we have reanalyzed Condit *et al*.'s Panama plot data. Dispersal is a purely spatial process: Progeny grow close to their parents when dispersal capacity is low. We used straight-line distances between plots to represent the dispersal process. Condit *et al*. provided four crucial environmental variables: elevation, precipitation, age of the forest stand, and the type of bedrock. We used similarities converted from normalized differences between plots to quantify each environmental variable, and the Steinhaus coefficient to quantify species similarity. Distance and the four environmental variables were all significant predictors of species similarity between plots in permutation-based multiple regressions. We then partitioned the variance in species similarity by computing multiple regressions of species similarity against distance only, environmental variables only, and both distance and environmental variables (*10*). Distance alone and environmental variables alone explained minor portions of the variation in species similarity (see the figure). Distance and environment together, however, explained 24% of the variation. The inability to separate distance and environment reflects a strong gradient in rainfall that is highly correlated with distance between Panamanian plots (*11*). Perhaps most important, 59% of the variation in species similarity remained unexplained by either distance or environment. In an analogous study, distance and environment explained just 16% of the variation in upland tree species composition between Colombian forest plots (*12*). This unexplained variance is typical for studies of tree species similarity in tropical forests.

Condit *et al*.'s approach is an important step toward predicting the effects of plant dispersal on species composition in the tropics. However, given that most of the variation in species similarity in tropical forests cannot be explained, there is a clear need for additional data and analyses before we fully understand the events that determine tropical forest diversity.

References and Notes

1. G. T. Prance, H. Beentje, J. Dransfield, R. Johns, *Ann. Mo. Bot. Gard.* **87**, 67 (2000).
2. World Conservation Monitoring Centre, *Global Diversity: Status of the Earth's Living Resources* (Chapman & Hall, London, 1992).
3. H. Ter Steege *et al.*, *J. Trop. Ecol.* **6**, 801 (2000).
4. R. Condit *et al.*, *Science* **295**, 666 (2002).
5. Current estimates in (*13*) for southeastern Amazonia Peru; (*14*) for Ecuadorian Amazonia; (*15*) for lowland Panama.
6. A. H. Gentry, *Ann. Mo. Bot. Gard.* **75**, 1 (1988).
7. S. P. Hubbell, *The Unified Neutral Theory of Biodiversity and Biogeography* (Princeton Univ. Press, Princeton, NJ, 2001).
8. When climate and edaphic variation are minimized by very short interplot distances, shade tolerance may largely control abundance. Understory sapling mortality is indicative of shade tolerance and explained 43% of the initial variation in abundance of 93 species of midstory and canopy trees between 10 and 99 mm in diameter on Barro Colorado Island (log-log relationship); data from (*16, 17*).
9. S. N. C. A. Pitman *et al.*, *Ecology* **82**, 2101 (2001).
10. J. M. Lobo, I. Castro, J. C. Moreno, *Biol. J. Linn. Soc.* **73**, 233 (2001).
11. C. R. Pyke, R. Condit, S. Aguilar, S. Lao, *J. Veg. Sci.* **12**, 553 (2001).
12. J. F. Duivenvoorden, *Vegetatio* **120**, 91 (1995).
13. L. Brako, J. L. Zarucchi, *Catalog of the Flowering Plants and Gymnosperms of Peru* (Missouri Botanical Garden, St. Louis, MO, 1993).
14. P. M. Jørgenson, S. León-Yánez, Eds., *Catalogue of the Vascular Plants of Ecuador* (Missouri Botanical Garden, St. Louis, MO, 1999).
15. W. G. D'Arcy, *Flora of Panama. Part I. Introduction and Checklist* (Missouri Botanical Garden, St. Louis, MO, 1987).
16. C. W. Welden, S. W. Hewett, S. P. Hubbell, R. B. Foster, *Ecology* **72**, 35 (1991).
17. R. Condit, S. P. Hubbell, R. B. Foster, *Ecol. Monogr.* **65**, 419 (1995).

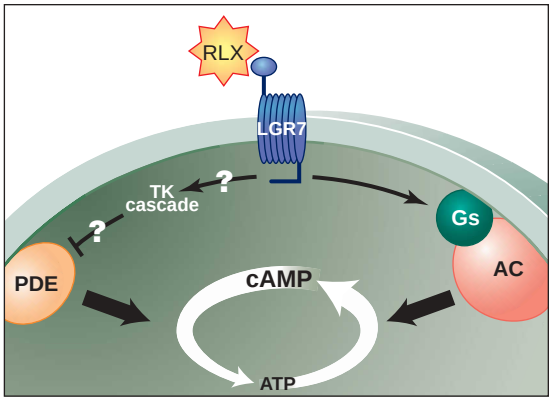
PERSPECTIVES: ENDOCRINOLOGY

This Hormone Has Been Relaxin' Too Long!

Richard Ivell

It is an irony of reproductive endocrinology that we are still seeking a receptor for the pregnancy hormone relaxin, one of the first reproductive hormones to be identified (*1*). Enter Hsu and colleagues (*2*) on page 671 of this issue to remedy the deficit. They describe two G protein–coupled, seven–transmembrane domain receptors (LGR7 and LGR8) that fulfill the requirements of a relaxin receptor.

On the one hand, the result is expected because relaxin is known to cause an increase in the concentration of intracellular cAMP in most (but not all) of its target tissues, consistent with its binding to a G protein–coupled receptor. Furthermore, the structural similarity of LGR7 and LGR8 to receptors for other reproductive peptide hormones, such as luteinizing hormone and follicle-stimulating hormone, suggests that all of these hormone receptors may share a common evolutionary origin. On the other hand, however, the Hsu *et al.* findings are unexpected because relaxin and its relative, relaxin-like factor (RLF/INSL3), structurally belong to another group of peptide hormones that includes insulin and IGF1. Logically, therefore, one might have expected the relaxin receptor to be an orphan membrane–associated tyrosine kinase receptor resembling those that bind to insulin and IGF1. Indeed, pharmacological evidence indicates that inhibitors of tyrosine kinase receptors block signal transduction by the relaxin receptor, and that relaxin can induce tyrosine phosphorylation and inhibition of a cell-specific phosphodiesterase, the enzyme that degrades cAMP (*3*, *4*) (see the figure).



A receptor for relaxin. The different signal transduction pathways involved in the up-regulation of cAMP by the peptide hormone relaxin (RLX). When relaxin binds to its G protein–coupled receptor, LGR7 or LGR8, a G protein signaling pathway is activated leading to stimulation of adenylate cyclase (AC) and an increase in cAMP (*2*). Binding of relaxin to its receptor also may activate a tyrosine kinase pathway that inhibits the activity of a phosphodiesterase (PDE) that degrades cAMP (*4*).

Relaxin regulates the growth and remodeling of reproductive tissues during late pregnancy. In model species, such as the pig, rat, and guinea pig, relaxin promotes expansion of the birth canal (loosening of the pubic symphysis and relaxation of the cervix) during parturition. In rats, relaxin also inhibits both spontaneous and oxytocin-induced contractions of the

The author is at the Institute for Hormone and Fertility Research, University of Hamburg, Grandweg 64, 22529 Hamburg, Germany. E-mail: ivell@ihf.de