

Developmental Biology

Volume 253, Issue 1, 1 January 2003, Pages 139-149

Regular Article

A Receptor Linked to a G_i -Family G-Protein Functions in Initiating Oocyte Maturation in Starfish but Not FrogsRebecca R. Kalinowski ^a ... Andrew F. Giusti ^{a, b, 1, 2}

Show more

<https://doi.org/10.1006/dbio.2002.0860>[Get rights and content](#)Under an Elsevier [user license](#)[open archive](#)

Abstract

The stimulation of oocyte maturation by 1-methyladenine in starfish, and by a steroid in frogs, has been proposed to involve G-protein-coupled receptors. To examine whether activation of receptors linked to G_i or G_z was sufficient to cause oocyte maturation, we expressed mammalian G_i - and G_z -linked receptors in starfish and frog oocytes. Application of the corresponding agonists caused meiosis to resume in the starfish but not the frog oocytes. We confirmed that the receptors were effectively expressed in the frog oocytes by using a chimeric G-protein, G_{qi} , that converts input from G_i - and G_z -linked receptors to a G_q output and results in a contraction of the oocyte's pigment. These results argue against G_i or G_z functioning to cause maturation in frog oocytes. Consistently, maturation-inducing steroids did not cause pigment contraction in frog oocytes expressing G_{qi} , and G_z protein was not detectable in frog oocytes. For starfish oocytes, however, our results support the conclusion that G_i functions in 1-methyladenine signaling and suggest the possibility of using frog oocyte pigment contraction as an assay to identify the 1-methyladenine receptor. To test this concept, we coexpressed G_{qi} and a starfish adenosine receptor in frog oocytes and showed that applying adenosine caused pigment contraction.

Keywords

G-protein; receptor; oocyte maturation; frog; starfish

[Recommended articles](#) [Citing articles \(21\)](#)

References

REFERENCES

- 1 E.C. Akam, R.A.J. Challiss, S.R. Nahorski
 $G_{q/11}$ and $G_{i/o}$ activation profiles in CHO cells expressing human muscarinic acetylcholine receptors: Dependence on agonist as well as receptor-subtype
Br. J. Pharmacol., 132 (2001), pp. 950-958
- 2 N. Ancellin, T. Hla
Differential pharmacological properties and signal transduction of the sphingosine 1-phosphate receptors EDG-4 and EDG-5

J. Biol. Chem., 274 (1999), pp. 18997-19002

- 3 M. Bayaa, R.A. Booth, Y. Sheng, X.J. Liu
The classical progesterone receptor mediates *Xenopus* oocyte maturation through a nongenomic mechanism
Proc. Natl. Acad. Sci. USA, 97 (2000), pp. 12607-12612
- 4 W.M. Bement, D.G. Capco
Activators of protein kinase C trigger cortical granule exocytosis, cortical contraction, and cleavage furrow formation in *Xenopus laevis* oocytes and eggs
J. Cell Biol., 108 (1989), pp. 885-892
- 5 L. Buck, R. Axel
A novel multigene family may encode odorant receptors: A molecular basis for odor recognition
Cell, 65 (1991), pp. 175-187
[Article](#)  [PDF \(3MB\)](#)
- 6 K. Chiba, R.T. Kado, L.A. Jaffe
Development of calcium release mechanisms during starfish oocyte maturation
Dev. Biol., 140 (1990), pp. 300-306
[Article](#)  [PDF \(1MB\)](#)
- 7 K. Chiba, H. Tadenuma, M. Matsumoto, K. Takahashi, T. Katada, M. Hoshi
The primary structure of the α subunit of a starfish guanosine-nucleotide-binding regulatory protein involved in 1-methyladenine-induced oocyte maturation
Eur. J. Biochem., 207 (1992), pp. 833-838
- 8 K. Chiba, K. Kontani, H. Tadenuma, T. Katada, M. Hoshi
Induction of starfish oocyte maturation by the $\beta\gamma$ subunit of starfish G protein and possible existence of the subsequent effector in cytoplasm
Mol. Biol. Cell, 4 (1993), pp. 1027-1034
- 9 M.F. Cicirelli, L.D. Smith
Cyclic AMP levels during the maturation of *Xenopus* oocytes
Dev. Biol., 108 (1985), pp. 254-258
[Article](#)  [PDF \(575KB\)](#)
- 10 M.D. Clark, G.D. Panopoulou, D.J. Cahill, K. Büsow, H. Lehrach
Construction and analysis of arrayed cDNA libraries
Methods Enzymol., 303 (1999), pp. 205-233
[Article](#)  [PDF \(5MB\)](#)
- 11 B.R. Conklin, Z. Farfel, K.D. Lustig, D. Julius, H.R. Bourne
Substitution of three amino acids switches receptor specificity of $G_q\alpha$ to that of $G_i\alpha$
Nature, 363 (1993), pp. 274-276
- 12 P. Coward, S.D.H. Chan, H.G. Wada, G.M. Humphries, B.R. Conklin
Chimeric G proteins allow a high-throughput signaling assay of G_i -coupled receptors
Anal. Biochem., 270 (1999), pp. 242-248
[Article](#)  [PDF \(86KB\)](#)
- 13 N.S. Duesbery, Y. Masui
Changes in protein association with intracellular membranes of *Xenopus laevis* oocytes during maturation and activation
Zygote, 1 (1993), pp. 129-141
- 14 J.E. Ferrell
***Xenopus* oocyte maturation: New lessons from a good egg**
BioEssays., 21 (1999), pp. 833-842
- 15 J. Finidori-Lepicard, S. Schorderet-Slatkine, J. Hanoune, E.-E. Baulieu
Progesterone inhibits membrane-bound adenylate cyclase in *Xenopus laevis* oocytes
Nature, 292 (1981), pp. 255-257
- 16 B.B. Fredholm, A.P. Ijzerman, K.A. Jacobson, K.-N. Klotz, J. Linden

- 17 R. Fujita, Y. Tamazawa, E.A. Barnard, M. Matsumoto
Blocking effect of serotonin on beta-adrenoceptor activity in follicle-enclosed *Xenopus* oocytes
Eur. J. Pharmacol., 240 (1993), pp. 213-217
[Article](#)  [PDF \(378KB\)](#)
- 18 C.J. Gallo, A.R. Hand, T.L.Z. Jones, L.A. Jaffe
Stimulation of *Xenopus* oocyte maturation by inhibition of the G-protein α_s subunit, a component of the plasma membrane and yolk platelet membranes
J. Cell Biol., 130 (1995), pp. 275-284
- 19 C.J. Gallo, T.L.Z. Jones, A.M. Aragay, L.A. Jaffe
Increased expression of α_q family G-proteins during oocyte maturation and early development of *Xenopus laevis*
Dev. Biol., 177 (1996), pp. 300-308
[Article](#)  [PDF \(298KB\)](#)
- 20 S. Gelerstein, H. Shapira, N. Dascal, R. Yekuel, Y. Oron
Is a decrease in cyclic AMP a necessary and sufficient signal for maturation of amphibian oocytes?
Dev. Biol., 127 (1988), pp. 25-32
[Article](#)  [PDF \(857KB\)](#)
- 21 M. Goodhardt, N. Ferry, M. Buscaglia, E.E. Baulieu, J. Hanoune
Does the guanine nucleotide regulatory protein Ni mediate progesterone inhibition of *Xenopus* oocyte adenylate cyclase?
EMBO J., 3 (1984), pp. 2653-2657
- 22 Y. Hiramoto
Microinjection of the live spermatozoa into sea urchin eggs
Exp. Cell Res., 27 (1962), pp. 416-426
[Article](#)  [PDF \(4MB\)](#)
- 23 G. Hollopeter, H.M. Jantzen, D. Vincent, G. Li, L. England, V. Ramakrishnan, R.B. Yang, P. Nurden, A. Nurden, D. Julius, P.B. Conley
Identification of the platelet ADP receptor targeted by antithrombotic drugs
Nature, 409 (2001), pp. 202-207
- 24 J. Iwashita, Y. Hayano, N. Sagata
Essential role of germinal vesicle material in the meiotic cell cycle of *Xenopus* oocytes
Proc. Natl. Acad. Sci. USA, 95 (1989), pp. 4392-4397
- 25 L.A. Jaffe, C.J. Gallo, R.H. Lee, Y.-K. Ho, T.L.Z. Jones
Oocyte maturation in starfish is mediated by the $\beta\gamma$ -subunit complex of a G-protein
J. Cell Biol., 121 (1993), pp. 775-783
- 26 H. Kanatani
Oocyte growth and maturation in starfish
C.B. Metz, A. Monroy (Eds.), Biology of Fertilization, Academic Press, Orlando (1985), pp. 119-140
[Article](#)  [PDF \(2MB\)](#)
- 27 H. Kanatani, Y. Hiramoto
Site of action of 1-methyladenine in inducing oocyte maturation in starfish
Exp. Cell Res., 61 (1970), pp. 280-284
[Article](#)  [PDF \(656KB\)](#)
- 28 E. Karsenti, R. Bravo, M. Kirschner
Phosphorylation changes associated with the early cell cycle in *Xenopus* eggs
Dev. Biol., 119 (1987), pp. 442-453
[Article](#)  [PDF \(7MB\)](#)
- 29 D.P. Kiehart
Microinjection of echinoderm eggs: Apparatus and procedures
Methods Cell Biol., 25 (1982), pp. 13-31
[Article](#)  [PDF \(2MB\)](#)

- 30 T. Kishimoto
Cell cycle arrest and release in starfish oocytes and eggs
Semin. Cell Dev. Biol., 9 (1998), pp. 549-557
[Article](#)  [PDF \(228KB\)](#)
- 31 P.A. Krieg, D.A. Melton
Functional messenger RNAs are produced by SP6 in vitro transcription of cloned cDNAs
Nucleic Acids Res., 12 (1984), pp. 7057-7070
- 32 E.R. Lazarowski, R.C. Boucher, T.K. Harden
Constitutive release of ATP and evidence for major contribution of ecto-nucleotide pyrophosphatase and nucleoside diphosphokinase to extracellular nucleotide concentrations
J. Biol. Chem., 275 (2000), pp. 31061-31068
- 33 P. Lemaire, N. Garrett, J.B. Gurdon
Expression cloning of *Siamois*, a *Xenopus* homeobox gene expressed in dorsal-vegetal cells of blastulae and able to induce a complete secondary axis
Cell, 81 (1995), pp. 85-94
[Article](#)  [PDF \(5MB\)](#)
- 34 F. Libert, M. Parmentier, A. Lefort, C. Dinsart, J. Van Sande, C. Maenhaut, M.-J. Simons, J.E. Dumont, G. Vassart
Selective amplification and cloning of four new members of the G protein-coupled receptor family
Science, 244 (1989), pp. 569-572
- 35 L.B. Lutz, B. Kim, D. Jahani, S.R. Hammes
G protein $\beta\gamma$ subunits inhibit nongenomic progesterone-induced signaling and maturation in *Xenopus laevis* oocytes
J. Biol. Chem., 275 (2000), pp. 41512-41520
- 36 C. Maenhaut, J. Van Sande, F. Libert, M. Abramowicz, M. Parmentier, J.-J. Vanderhaegen, J.E. Dumont, G. Vassart, S. Schiffmann
RDC8 codes for an adenosine A2 receptor with physiological constitutive activity
Biochem. Biophys. Res. Commun., 173 (1990), pp. 1169-1178
[Article](#)  [PDF \(3MB\)](#)
- 37 L.C. Mahan, L.D. McVittie, E.M. Smyk-Randall, H. Nakata, F.J. Monsma, C.R. Gerfen, D.R. Sibley
Cloning and expression of an A1 adenosine receptor from rat brain
Mol. Pharmacol., 40 (1991), pp. 1-7
- 38 J.L. Maller
The elusive progesterone receptor in *Xenopus* oocytes
Proc. Natl. Acad. Sci. USA, 98 (2001), pp. 8-10
- 39 J.L. Maller, E.G. Krebs
Progesterone-stimulated meiotic cell division in *Xenopus* oocytes
J. Biol. Chem., 252 (1977), pp. 1712-1718
- 40 R. Maroto, O.P. Hamill
Brefeldin A block of integrin-dependent mechanosensitive ATP release from *Xenopus* oocytes reveals a novel mechanism of mechanotransduction
J. Biol. Chem., 276 (2001), pp. 23867-23872
- 41 Y. Masui, H. Clarke
Oocyte maturation
Int. Rev. Cytol., 57 (1979), pp. 185-282
[Article](#)  [PDF \(6MB\)](#)
- 42 Y. Masui, E.K. Shibuya
Development of cytoplasmic activities that control chromosome cycles during maturation of amphibian oocytes
R. Schlegel, M.S. Halleck, P.N. Roa (Eds.), Molecular Regulation of Nuclear Events in Mitosis and Meiosis, Academic Press, Orlando (1987), pp. 1-42
[Article](#)  [PDF \(3MB\)](#)
- 43 L. Meijer, P. Zarutskie

Starfish oocyte maturation: 1-Methyladenine triggers a drop of cAMP concentration related to the hormone-dependent period

Dev. Biol., 121 (1987), pp. 306-315

[Article](#)  [PDF \(1MB\)](#)

- 44 L. Meijer, W. Dostmann, H.G. Genieser, E. Butt, B. Jastorff

Starfish oocyte maturation: Evidence for a cyclic AMP-dependent inhibitory pathway

Dev. Biol., 133 (1989), pp. 58-66

[Article](#)  [PDF \(1000KB\)](#)

- 45 O. Mulner, F. Megret, J.E. Alouf, R. Ozon

Pertussis toxin facilitates the progesterone-induced maturation of *Xenopus* oocyte

FEBS Lett., 181 (1985), pp. 397-402

[Article](#)  [PDF \(613KB\)](#)

- 46 S.J. Noh, J.K. Han

Inhibition of the adenylyl cyclase and activation of the phosphatidylinositol pathway in oocytes through expression of serotonin receptors does not induce oocyte maturation

J. Exp. Zool., 280 (1998), pp. 45-56

- 47 S. Offermanns, T. Wieland, D. Homann, J. Sandmann, E. Bombien, K. Spicher, G. Schultz, K.H. Jakobs

Transfected muscarinic acetylcholine receptors selectively couple to G_i-type G proteins and G_{q/11}

Mol. Pharmacol., 45 (1994), pp. 890-898

- 48 E. Okumura, T. Fukuhara, H. Yoshida, S. Hanada, R. Kozutsumi, M. Mori, K. Tachibana, T. Kishimoto

Akt inhibits Myt1 in the signalling pathway that leads to meiotic G2/M-phase transition

Nat. Cell Biol., 4 (2002), pp. 111-116

- 49 J. Olate, C.C. Allende, J.E. Allende, R.D. Sekura, L. Birnbaumer

Oocyte adenylyl cyclase contains N_i, yet the guanine nucleotide-dependent inhibition by progesterone is not sensitive to pertussis toxin

FEBS Lett., 175 (1984), pp. 25-30

- 50 E.M. Parker, K. Kameyama, T. Higashijima, E.M. Ross

Reconstitutionally active G protein-coupled receptors purified from baculovirus-infected insect cells

J. Biol. Chem., 266 (1991), pp. 519-527

- 51 M. Parmentier, F. Libert, C. Maenhaut, A. Lefort, C. Gérard, J. Perret, J. Van Sande, J.E. Dumont, G. Vassart

Molecular cloning of the thyrotropin receptor

Science, 246 (1989), pp. 1620-1622

- 52 M. Parmentier, F. Libert, S. Schurmans, S. Schiffmann, A. Lefort, D. Eggerickx, C. Ledent, C. Mollereau, C. Gérard, J. Perret, A. Grootegoed, G. Vassart

Expression of members of the putative olfactory receptor gene family in mammalian germ cells

Nature, 355 (1992), pp. 453-455

- 53 M.-L. Parmentier, C. Joly, S. Restituto, J. Bockaert, Y. Grau, J.-P. Pin

The G protein-coupling profile of metabotropic glutamate receptors, as determined with exogenous G proteins, is independent of their ligand recognition domain

Mol. Pharmacol., 53 (1998), pp. 778-786

- 54 V. Pellaz, S. Schorderet-Slatkine

Evidence for a pertussis toxin-sensitive G protein involved in the control of meiotic reinitiation of *Xenopus laevis* oocytes

Exp. Cell Res., 183 (1989), pp. 245-250

[Article](#)  [PDF \(378KB\)](#)

- 55 X. Romo, M.V. Hinrichs, L. Guzmán, J. Olate

Gas levels regulate *Xenopus laevis* oocyte maturation

Mol. Reprod. Dev., 63 (2002), pp. 104-109

- 56 S.E. Sadler, J.L. Maller

Progesterone inhibits adenylate cyclase in *Xenopus* oocytes. Action on the guanine nucleotide regulatory protein

J. Biol. Chem., 256 (1981), pp. 6368-6373

- 57 C.F. G. "H. Maller"

- 57 S.E. Sadler, J.L. Maller
Inhibition of *Xenopus* oocyte adenylate cyclase by progesterone: A novel mechanism of action
Adv. Cyclic Nucleotide Protein Phosphorylation Res., 19 (1985), pp. 179-194
- 58 S.E. Sadler, J.L. Maller, D.M.F. Cooper
Progesterone inhibition of *Xenopus* oocyte adenylate cyclase is not mediated via the *Bordetella pertussis* toxin substrate
Mol. Pharmacol., 26 (1984), pp. 526-531
- 59 K.C. Sadler, J.V. Ruderman
Components of the signaling pathway linking the 1-methyladenine receptor to MPF activation and maturation in starfish oocytes
Dev. Biol., 197 (1998), pp. 25-38
[Article](#)  [PDF \(1MB\)](#)
- 60 J. Sambrook, D.W. Russell
Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory Press, Cold Spring Harbor (2001)
- 61 Y. Sheng, M. Tiberi, R.A. Booth, C. Ma, X.J. Liu
Regulation of *Xenopus* oocyte meiosis arrest by G protein $\beta\gamma$ subunits
Curr. Biol., 11 (2001), pp. 405-416
[Article](#)  [PDF \(556KB\)](#)
- 62 F. Shilling, K. Chiba, M. Hoshi, T. Kishimoto, L.A. Jaffe
Pertussis toxin inhibits 1-methyladenine-induced maturation in starfish oocytes
Dev. Biol., 133 (1989), pp. 605-608
[Article](#)  [PDF \(1MB\)](#)
- 63 F. Shilling, G. Mandel, L.A. Jaffe
Activation by serotonin of starfish eggs expressing the rat serotonin 1c receptor
Cell Regul., 1 (1990), pp. 465-469
- 64 W.F. Simonds
G protein regulation of adenylate cyclase
Trends Pharmacol. Sci., 20 (1999), pp. 66-73
[Article](#)  [PDF \(667KB\)](#)
- 65 L.D. Smith, W. Xu, R.L. Varnold
Oogenesis and oocyte isolation
Methods Cell Biol., 36 (1991), pp. 45-60
[Article](#)  [PDF \(1MB\)](#)
- 66 S.F. Steinberg, L.L. Brunton
Compartmentation of G-protein-coupled signaling pathways in cardiac myocytes
Annu. Rev. Pharmacol. Toxicol., 41 (2001), pp. 751-773
- 67 H. Tadenuma, K. Takahashi, K. Chiba, M. Hoshi, T. Katada
Properties of 1-methyladenine receptors in starfish oocyte membranes: Involvement of pertussis toxin-sensitive GTP-binding protein in the receptor-mediated signal transduction
Biochem. Biophys. Res. Commun., 186 (1992), pp. 114-121
[Article](#)  [PDF \(847KB\)](#)
- 68 T.L. Tang, R.M. Freeman, A.M. O'Reilly, B.G. Neel, S.Y. Sokol
The SH2-containing protein-tyrosine phosphatase SH-PTP2 is required upstream of MAP kinase for early *Xenopus* development
Cell, 80 (1995), pp. 473-483
[Article](#)  [PDF \(4MB\)](#)
- 69 R. Taussig, W.J. Tang, J.R. Hepler, A.G. Gilman
Distinct patterns of bidirectional regulation of mammalian adenylyl cyclases
J. Biol. Chem., 269 (1994), pp. 6093-6100
- 70 J. Tian, S. Kim, E. Heilig, J.V. Ruderman
Identification of XPR-1, a progesterone receptor required for *Xenopus* oocyte activation
Proc. Natl. Acad. Sci. USA, 97 (2000), pp. 14358-14363
- 71 M. Torreón V. Echeverri & #x0301;a G. Retamales I. Herrera M.V. Hinrichs J. Olata

Molecular cloning and expression of an adenylyl cyclase from *Xenopus laevis* oocytes

FEBS Lett., 404 (1997), pp. 91-94

[Article](#)  [PDF \(481KB\)](#)

- 72 A.P. Wiemelt, M.J. Engleka, A.F. Skorupa, F.A. McMorris

Immunochemical visualization and quantitation of cyclic AMP in single cells

J. Biol. Chem., 272 (1997), pp. 31489-31495

- 73 A. Wise, M. Sheehan, S. Rees, M. Lee, G. Milligan

Comparative analysis of the efficacy of A_1 adenosine receptor activation of $G_{i/o\alpha}$ G proteins following coexpression of receptor and G protein and expression of A_1 adenosine receptor- $G_{i/o\alpha}$ fusion proteins

Biochemistry, 38 (1999), pp. 2272-2278

- 74 Y.H. Wong, B.R. Conklin, H.R. Bourne

$G_{\alpha 2}$ -mediated hormonal inhibition of cyclic AMP accumulation

Science, 255 (1992), pp. 339-342

- 75 S. Yousefi, P.R. Cooper, S.L. Potter, B. Mueck, G. Jarai

Cloning and expression analysis of a novel G-protein-coupled receptor selectively expressed on granulocytes

J. Leukocyte Biol., 69 (2001), pp. 1045-1052

- 2 E-mail address for correspondence: agiusti@remedyne.com, ljaffe@neuron.uchc.edu.

- 1 Present address and to whom correspondence should be addressed at Remedyne Corporation, 2219 Bath Street, Santa Barbara, CA 93105.
Fax: (805) 687-3393.

Copyright © 2002 Elsevier Science (USA). All rights reserved.

ELSEVIER

[About ScienceDirect](#) [Remote access](#) [Shopping cart](#) [Contact and support](#) [Terms and conditions](#) [Privacy policy](#)

Cookies are used by this site. For more information, visit the [cookies page](#).

Copyright © 2017 Elsevier B.V. or its licensors or contributors. ScienceDirect ® is a registered trademark of Elsevier B.V.

 RELX Group™