

## Dario DiFrancesco

### Curriculum vitae

#### Personale

Nato a Milano 10/2/1948

Sposato con Marina Morini; figli Jacopo Cosimo (nato a Oxford 11/11/1978); gemelli Mattia Lorenzo e Niccolò Ettore (nati a Milano 11/20/1982).

Prof. Ord. di Fisiologia, Dip di Bioscienze, The Pacelab, Un. di Milano, via Celoria 26, 20133 Milano  
Tel. 02-5031-4931; fax: 5031-4932; em: dario.difrancesco@unimi.it

#### Studi

Università degli Studi di Milano, Laurea Scienze Fisiche Applicazioni Biologiche 1973 (110/110 lode)

The Physiological Laboratory, University of Cambridge, UK: Postdoc

University Lab. of Physiology, Oxford, UK: Postdoc

#### Posizioni di Ricerca e Accademiche

9/73- 12/74: Borsa Ricerca e Insegnamento, Ist di Fisiologia Generale, Univ. Milano.

1/74- 12/80: Contrattista, come sopra

9/76- 3/77: Postdoctoral fellow a Cambridge, The Physiological Laboratory (R.D. Keynes)

4/77- 12/78: Postdoc in Cardiac Electrophysiology a Oxford, The Lab. of Physiology (Denis Noble).

1/81- 5/86: Ricercatore, Dip. Fisiologia e Biochimica Generali, Univ. Milano.

dal 6/86: Prof. Ordinario, Dip. Fisiologia e Biochimica Generali, poi Dip di Bioscienze, Univ. Milano

dal 10/99: Docente di Fisiologia presso l'Università Vita-Salute San Raffaele, Milano

#### Aree di Ricerca

-Elettrofisiologia cellulare cardiaca

-Correnti ioniche e attività ritmica del cuore

-Il canale "pacemaker "funny" e il controllo della frequenza cardiaca

-Farmacologia del controllo cronotropico (ivabradina)

-Aritmie cardiache associate a mutazioni dei canali "funny" (HCN4)

-Cellule staminali cardiache e pacemaker "biologico"

#### Premi e Riconoscimenti

-Borsa di scambio scientifico Accademia dei Lincei- Royal Society 9/1976- 8/1977 (Cambridge, UK)

- Wellcome Trust award Research Grants 9/1977- 7/1979 (Oxford, UK)

- Premio Wallace O. Fenn Memorial Fund per XXVIII Congresso IUPS 1980 (Budapest)

- Premio Wallace O. Fenn Memorial Fund per for XXIX Congresso IUPS 1983 (Sidney)

-Membro della "Accademia Europaea" dal 1992

-Premio internazionale di Fisiologia "Professeur Pierre Rijlant" Academic Foundation, assegnato dalla Accademia Reale di Medicina del Belgio, 1994

-Lectio Magistralis Congresso Annuale Soc Italiana Fisiologia, 1994

-Menzione L.E.R.U. Research Breakthroughs 2006 in rappresentanza dell' Università di Milano

-Grand Prix Scientifique anno 2008, assegnato dalla Accademia Francese (Fondation Lefoulon-Delalande- Institut de France), con la motivazione: "Pour les très remarquables travaux de recherche qui ont conduit à la découverte des canaux ioniques impliqué dans la régulation du rythme cardiaque".

-Lectio Magistralis Facoltà di Scienze Univ. Milano 2008

-Lectio Magistralis e Premio "Translation in Cardiomyopathies: from genes to therapy" Padova 2009

-H.C. Burger Award Lecture 23mo Cong. Europ. Soc. Noninvasive Preventive Cardiol., Brescia 2009

-Socio corrispondente, Istituto Lombardo Accademia di Scienze e Lettere

-Consultato annualmente dal Comitato Nobel Prize in Physiology or Medicine dal 1997

#### Finanziamenti Extra-murali (selezione)

-CNR International Research Grant (Milano- Oxford) 1982/86, 1987-89, 1990-93

-CNR Research Grant 1989-90

-MDA Basic Research Grant 1985/87

-NIH Research Grant 1987/1989

-CNR Progetto speciale "Canali ionici" (Coordinatore) 1991-1993

-European Union Human Capital and Mobility grant 1995-1997

-Telethon Grant (1998/2001)

-NATO exchange grant 1998-1999 (Columbia University)

- Servier International 1999-2000; 2002-2003; 2005-2006, 2007-2009, 2010-2012
- MIUR FISR CNR Genomica Funzionale. funzioni di gruppi di geni a livello cellulare 2003-2005
- FIRB Neurobiologia Analisi sperimentale e modellistica ...del sistema nervoso centrale 2003-2007
- FIRB Fisiologia e Ingegneria Cellulare 2004-2007
- FIRB Laboratorio FIRB di Scienze Cardiovascolari 2005-2010
- CARIPLO Il Pacemaker Biologico 2005-2007
- UE Normacor Normal Cardiac Excitation: Generation, Propagation, Coupling to Contraction 2006-9
- MURST Cofin-PRIN dal 1997 con continuità

### **Società Scientifiche**

- Società Italiana di Fisiologia, 1973-
- Società Italiana di Biofisica, 1984-1989
- Associazione di Biologia Cellulare e del Differenziamento 1987-1990
- The Physiological Society (UK) 1983-
- American Physiological Society, 1985-
- Biophysical Society (USA), 1999-
- Society for Neuroscience (USA), 2011-

### **Esperienza Editoriale, Consulenze, Comitati.**

- Boards: Journal of Cardiovascular Electrophysiology, 1992-2000
- News In Physiological Sciences (NIPS), 1995-2002
- Journal of Cardiovascular Pharmacology, 1996-2000
- British Journal of Pharmacology, 2003-2007
- Frontiers in Cardiac Electrophysiology, 2011-
- Ad hoc reviewer per tutte le più importanti riviste scientifiche.
- Coordinatore Nazionale Gruppo CNR "Ionic Channels: functions and control mechanisms" 1991-93
- Commissaire de thèse de troisième cycle: Docteur Guy Champigny, Université de Poitiers, 6/1987
- Commissaire de thèse de troisième cycle: Docteur Patrick Bois, Université de Poitiers 12/1989
- Commissaire de thèse de troisième cycle: Docteur Jerome Petit-Jacques, Université de Poitiers 1/1993
- Consulente N.I.H. PPG: Ira S. Cohen, SUNY at Stony Brook, N.Y., 1988-92
- Consulente, N.I.H. PPG: Michael Rosen, Columbia Univ., New York, 1993-98 e ulteriori rinnovi
- Commissaire de thèse de troisième cycle: Docteur Jocelin Bescond, Université de Poitiers 12/1996
- Commissaire de thèse de troisième cycle: Docteur Barbara Renaudon, Université de Poitiers 12/1997
- Grant reviewer NATO research project 9/1997
- Esperto europeo valutaz. INSERM U446 (R. Fishmeister) Un. Paris Sud, Châtenay-Malabry, 9/1999
- Grant reviewer Human Frontiers 1/2003
- Commissaire de thèse de Doctorat Marie Curie: Docteur Angelo Torrente, Un. Montpellier 07/2011
- Grant reviewer per la Fondation de Recherche Médicale 7/2011
- Esaminatore Tesi D. Phil. Dr Michael A. Colman, Univ. Manchester 12/2012
- Grant reviewer per MIUR e altri Istituzioni nazionali e internazionali di finanziamento della ricerca.

### **Esperienza di ricerca**

- 7/73 - 7/76: Borsista Ricerca e Insegnamento, Istituto di Fisiologia Generale, Un. Milano.
- 7/76 - 3/79: PostDoc presso il Physiological Lab, Cambridge, e quindi Lab. of Physiology, Oxford
- 3/79 - 12/80: Wellcome Trust Fellowship presso Un. Univ. Lab. of Physiology a Oxford. Brevi periodi di ricerca presso Laboratori di Fisiologia: Homburg/Saar, Paris XI, Tours.
- 3/79 - 12/80: Contrattista, Istituto di Fisiologia e Biochimica Generali, Un. Milano.
- 1/81 - 6/86: Ricercatore Istituto di Fisiologia e Biochimica Generali, Univ. di Milano.
- dal 6/86 – PO di Fisiologia, Dip. di Fisiologia e Biochimica Generali, poi Dip Bioscienze, Un. Milano.
- 6/86 - 8/86, 6/88 - 8/88, 6/90 - 8/90: Visiting Professor, SUNY at Stony Brook, NY
- Visiting scientist, Dept. Pharmacology Columbia University, N.Y. periodicamente dal 1990

### **Media**

Articoli di stampa, interviste giornalistiche, citazioni, interviste video e altro materiale è consultabile sulla pagina web <http://users.unimi.it/difrancesco/>

### **Dati Bibliometrici**

-> 170 Articoli/reviews/capitoli di libri. H-index: 57; citations: 11981 (Google Scholar 07/2013); la pagina di Google Scholar è pubblica: <http://scholar.google.it/citations?user=BjMvgjYAAAAJ>

## **Presentazioni su invito a congressi, seminari, named lectures**

- 1977 1. -Oxford, Lunch Club Seminar
- 1978 2. -Bonn (O. Hauswirth)
- 1979 3. -Paris XI (E. Coraboeuf)
- 1980 4. -Budapest, Inv. Lecturer XXVIII IUPS Congress  
5. -Amsterdam, Symposium: Cardiac Rate and Rhythm
- 1981 6. -Abano Terme, Fidia Res. Lab. (A. Gorio)  
7. -Lyon (O. Rougier).
- 1982 8. -Firenze (A. Mugelli)  
9. -Ferrara (E. Wanke)
- 1983 10. -Geneve, Centre Med. Univ. (D. Bertrand, C. Bader)  
11. -Abano Terme, Fidia Res. Lab. (M. Prosdocimi)  
12. -Sidney, Invited Lecturer XXIX IUPS Congress
- 1984 13. -Clermont-Ferrand (Merck-Sharp & Dhome-Chibret)  
14. -Tours (D. Garnier)  
15. -Oklahoma City, Inv. Lecturer Symp. Int. Society for Heart Research (R. Lazzara)  
16. -Atlanta (L. DeFelice)  
17. -Baltimore (J. Lederer, T. Lakatta)  
18. -Stony Brook (I. Cohen)  
19. -New York, Columbia University (M. Rosen)
- 1985 20. -Napoli (T. De Leo)  
21. -Torino (E. Meda)  
22. -Pisa, Inv. Speaker SIF
- 1986 23. -Banff, Speaker Sat. Symposium IUPS Congress  
24. -New York, Columbia Univ  
25. -Vienna, Inv. Lecturer Symp. Boehringer Ingelheim
- 1987 26. -Rotterdam, Lecturer Symp. Pure Bradycardic Agents  
27. -Milano, CNR  
28. -Padova, (S. Luciani)  
29. -Poitiers, Committee Board Thesis Guy Champigny  
30. -San Diego, Inv. Lecturer Congress APS
- 1988 31. -Okazaki, Chairman Symp. US-Japan seminar  
32. -Tokio, Inv. Lecturer International Symp Basic Mechanisms of Arrhythmias (H. Irisawa)  
33. -Padova, Inv. Lecturer Congress SIB  
34. -Spoleto, Inv. Lecturer Congress ABCD  
35. -Pasadena, (H. Lester)  
36. -London, Inv. Co-chairman, British Heart Foundation
- 1989 37. -Pavia, Conference Dottorato Fisiologia (Prof. Rindi)  
38. -Ann Arbor, Inv. Speaker Int. Soc. Heart Research  
39. -Homburg/Saar, Chairman Symp to honor W. Trautwein  
40. -Roma, Inv. Speaker Soc. Ital. Cardiologia  
41. -Poitiers, Committee Board thesis Patrick Bois
- 1990 42. -Frankfurt, Inv. Speaker Symp. A.Thomae  
43. -New York, Columbia Univ.  
44. -Chicago, Inv. Speaker Symp. Ion channels in heart and the vascular system (H. Fozzard)  
45. -Houston (A.M. Brown)  
46. -Farmington (A. Pappano)  
47. -New London, Inv. Speaker Gordon Conference Ionic Channels (H. Lester)  
48. -Firenze, Inv. Lecturer III Congr. Cell Biol.  
49. -Perugia, Inv. Speaker Congress SIF  
50. -Firenze, Inv. Speaker XVII Int. Congr. Electrophysiology  
51. -Islamorada, Florida, Inv. Speaker Hoffman Symp. (M. Rosen)
- 1991 52. -Il Ciocco, Inv. Speaker NATO Workshop (M. Morad)  
53. -Roma, Un. Tor Vergata (S. Morante)  
54. -Prague, Inv. Speaker Regional Meeting IUPS (C. Hartzell)  
55. -Oxford, Inv. Speaker Symp. Cardiac Background Currents (D. Noble)  
56. -Erice, Inv. Lecturer Int. School Bioelectrochemistry  
57. -Milano, Inv. Lecturer Scuola Soc. It. Neuroscienze
- 1992 58. -Pisa, (L. Maffei)  
59. -Seattle, WA (B. Hille, W. Crill)

60. -San Diego, CA (K. Chien)  
61. -Padova, (S. Schiaffino)  
62. -Madrid, Inv. Speaker X Int. Congr. Cell Biology  
63. -Ferrara, Inv. Speaker meeting EWGCE  
64. -Naples, Inv. Speaker Nat. Congr. Pharmacology  
65. -Antwerpen (PP. van Bogaert)  
66. -Bologna (C. Rapisarda)  
67. -Vienna Inv. Lecturer Symposium Boehringer Ingelheim  
1993 68. -Glasgow, Inv. Speaker XXXII IUPS Congress  
69. -Keystone, Colorado, Inv. Lecturer Symp. Cardiac Electrophysiology Medtronic)  
70. -Milano, Inv. Speaker ABCD Congress  
71. -Poitiers, Inv. Lecturer "E. Coraboeuf Jubilee"  
1994 72. -Firenze, Lettura Magistrale Annuale Soc. Ital. Fisiologia  
73. -Montpellier (Sanofi Recherche)  
74. -Trento (R. Antolini)  
75. -Milano, DiBit (Neurobiology Course Open Univ.)  
76. -Palermo, Invited Speaker Congress SIBPA  
1995 77. -Versailles, Inv. Speaker Workshop Bradycardic Agents and Cardiac Arrhythmias (Servier)  
78. -Trieste, SISSA (E. Cherubini)  
79. -Leuven, Symposium to honor E. Carmeliet  
80. -Bruxelles, Lecture for *Prof. Pierre Rijnlant Prize* at Royal Academy of Medicine  
81. -London, King's Coll, Symposium on Cyclic-nucleotide gated channels  
82. -New York, Columbia Un. (R. Robinson)  
1996 83. -Banff, Inv. Speaker Symp. in honour of Denis Noble  
84. -Banff, Inv. Speaker Conference AV node  
1997 85. -Nice-Sophia Antipolis (M. Lazdunski)  
86. -Erice, Symposium Synaptic Communication (E. Cherubini)  
87. -St. Petersburg, Inv. speaker Symposium Cell Oscillators (A. Noma)  
1998 88. -Jülich (B. Kaupp)  
1999 89. -Miami, 2<sup>nd</sup> Workshop Cardiac rate inhibitors. (Servier)  
90. -Rome, Ph.D. school seminar (A. Trentalance)  
91. -Orsay, Inv. speaker E. Coraboeuf Symposium (R. Fishmeister)  
92. -Oxford, Session Chairman XXIII meeting EWGCCE (Denis Noble)  
93. -Hyeres, Inv. speaker Colloque Canaux Ioniques (S. Richard)  
94. -Rome, Inv. speaker Hodgkin Symposium  
2000 95. -Milano Dept. Pharmacology (A. Panerai)  
96. -Parma, Inv. speaker SIBPA Congress  
2001 97. -New York, Columbia Un. (R. Robinson)  
98. -Paris, Inv. speaker 3<sup>rd</sup> Workshop Cardiac rate inhibitors. (Servier)  
99. -Ancona, Inv. speaker Congresso SIF  
100. -Goettingen (D.W. Richter, E. Neher)  
2002 101. -Courbevois Paris seminar (Servier)  
102. -Berlin, Inv. speaker Eur. Soc. Cardiol. Congress 2002  
103. -Leeds, Inv. speaker Physiol. Soc. meeting  
104. -Montpellier, Inv. chair EWGCCE 2002 meeting  
2003 105. -Courbevois Paris seminar (Servier)  
106. -Les Arcs, Inv. speaker European Winter Conference on Brain Research  
107. -Milano, Organizer Symposium to honor A. Ferroni  
108. -Strasbourg, Inv. speaker Heart Failure Congress ISHR 2003  
109. -Vienna, Inv. speaker Eur. Soc. Cardiol. Congress 2003  
110. -Erice, Inv. speaker 2nd L. & H. Fairberg Workshop Cardiac Engineering  
111. -Milano, Ph.D. School in Physics seminar (PF Bortignon)  
112. -Milano, Accademia dei Lincei (F. Clementi)  
2004 113. -Milano, Newron seminar  
114. -Sidney, Inv. speaker XVIII World Congress Intern. Soc. Heart Research  
115. -Montpellier, Inv. speaker Cardiac Cell. Electrophysiol: From funny currents to the current Physiome, Celebration for Denis Noble retirement  
116. -Napoli, Inv. speaker VI Convegno Nazionale INBB  
117. -Roma, Inv. speaker 65<sup>o</sup> Congresso Naz. Soc. Italiana Cardiologia  
2005 118. -Milano, Newron Pharmaceutical (R.G. Fariello)

119. -Roma, Istituto Dermopatico Immacolata (M. Capogrossi)
120. -New York, Dept. Pharmacol. Columbia Univ. (R.B. Robinson) (no seminar)
121. -Milano, CC Monzino (M. Pesce)
122. -Neully sur Seine, Procoralan Meeting (Servier)
- 2006 123. -S. Francisco, Inv. speaker Exp. Biology meeting FASEB (S.Siegelbaum)
124. -Athens, Inv. speaker Cardiology Update 2006 Evangelismos General Hospital
125. -Milano, H San Raffaele (A. Malgaroli)
- 2007 126. -Darmstadt (G. Thiel)
127. -Bologna, Inv. speaker XIX World Congress Intern. Soc. Heart Research
128. -Manchester, Inv. speaker Cardiac Electrophysiol. meeting (M. Boyett)
129. -Antalya, Inv. speaker 5<sup>th</sup> Fairberg workshop (S. Sideman)
130. -Lugano, Inv. speaker Cardiocentro Ticino Cong Cardiac Frequency (T.Moccetti)
- 2008 131. -Vellere, India, Inv. speaker 6<sup>th</sup> Winter Symp. Cardio. Sciences
132. -Geneve, Hôpitaux Universitaires de Genève -Servier (B. Wagner)
133. -Athens, Inv. speaker XXVIII Europ. Section Meeting ISHR
134. -Paris, Coupole Institut de France, Grand Prix Scientifique Fondation Lefoulon-Delalande
135. -Milano, Keynote Lecture Giornate del Gruppo Biologico
136. -Sassari seminar Dip. Scienze Biomediche (L. Deiana)
137. -New London, NH Inv. speaker Gordon Res. Conference Colby-Sawyer Cardiac Regulatory Mechanisms (D. Eisner, J. Lederer)
138. -Imola XV Cong. Soc. Ital. Ric. Cardiovasc. (G. Losano)
139. -Milano Inv. speaker Circolo della Stampa, Premio Galeno 2008 (R. Paoletti)
140. -Roma Inv. speaker Giornate Ricerca Servier (B. Millet)
141. -Venice Inv. speaker Multiple Risk Factors in CVD Venezia Lido (R. Paoletti)
142. -St Louis, MO CBAC Seminar (Y. Rudy)
143. -New Orleans Inv. speaker CES Annual Meeting
144. -Milano, Lectio Magistralis Faculty of Science Univ. Milan
- 2009 145. -Paris Croissy, seminar Servier (L. Alliot)
146. -Il Ciocco, chair session GRC Cardiac Arrhythmia Mechanisms (N. Trayanova)
147. -Milano, Lecture Istituto Lombardo Accademia Scienze e Lettere
148. -Padova, Lectio Magistralis and Prize Symp. "Translation in Cardiomyopathies: from genes to therapy" (G. Thiene)
149. -Boston Inv. speaker Heart Rhythm 2009 Cong. (D. Packer)
150. -Brescia, H.C. Burger Award Lecture "The history of the discovery of funny channels" 23rd Cong. Europ. Soc. Noninvasive Preventive Cardiol. (C. Rusconi)
151. -Paris Suresnes, seminar/talks Servier (J.-P. Vilaine)
152. -Berlin, Inv. speaker Europace 2009 Cong. (J. Brugada)
153. -Lousanne, Inv. lecturer Colloques Formation Continue, CHUV (Andres Jaussi)
154. -Kyoto, Inv. speaker 36<sup>o</sup> IUPS Cong. "Pacemaker mechanisms" (D. Eisner, D. Noble); organizer & speaker Luncheon Seminar "Targeting f- channels for clinical applications"
155. -Ovodda, Sardinia, Lecturer meeting "Studio comparativo della longevità di quattro comuni della Sardegna (Ovodda, Tiana, Erula e Perfugas)" (L. Deiana)
- 2010 156. -Levico Terme, Inv. speaker Congress SICOA -Le aritmie nel III millennio
157. -Nice, Inv. speaker Cardiosim 2010, 10th World Congr. Cardiac Arrhythmias
- 2011 158. -Milano Ist Besta (S. Franceschetti)
159. -Venice, Inv. speaker 2011 Venice Arrhythmias Congress (Raviele, Natale)
160. -Porto, Inv. speaker Reunião Anual Núcleo Técnicos Cardiologia da SPC (Medtronic)
161. -Roma, Inv. speaker Advances in Cardiac Electrophysiology (Calò)
162. -Roma, Inv. speaker Soc Ital Cardiol
- 2012 163. -Milano, Lecture Istituto Lombardo Accademia Scienze e Lettere
164. -Boston, Inv. speaker Heart Rhythm 33rd Annual Sci Sessions
165. -Paris Suresnes, Servier seminar (J.-P. Vilaine)
166. -Manchester, Inv. speaker Phys.Soc.CardiacResp Meeting Card Arrhythmias (H Zhang)
- 2013 167. -Pavia, Inv. Lecturer PhD School Collegio Borromeo (V. Ricci)
168. -Montpellier, Inv. Lecturer Colloque du Patch-Club
169. -Paris Suresnes, Servier seminar (J.-P. Vilaine, C. Thollon)
170. -Birmingham, Inv. speaker XXXVII IUPS 2013 Congress (M. Boyett, H. Dobryznski)

## Dario DiFrancesco- Pubblicazioni

### Articoli

1. -DiFrancesco,D. & McNaughton,P.A. (1979) The effects of Calcium on outward membrane currents in the cardiac Purkinje fibres. **J.Physiol.** 289, 347-373
2. -Brown,H.F., DiFrancesco,D. & Noble,S.J. (1979a) How does adrenaline accelerate the heart? **Nature**, 280, 235-236
3. -DiFrancesco,D., Ohba,M. & Ojeda,C. (1979) Measurement and significance of the reversal potential for the pacemaker current  $i_{K2}$  in Purkinje fibres. **J.Physiol.** 297, 135-162
4. -Brown,H.F., DiFrancesco,D. & Noble,S.J. (1979b) Cardiac pacemaker oscillation and its modulation by autonomic transmitters. **J.Exp.Biol.** 81, 175-204
5. -DiFrancesco,D., Noma,A. & Trautwein,W. (1979) Kinetics and magnitude of the time-dependent potassium current in the rabbit sino-atrial node: effect of external potassium. **Pflügers Arch.** 381, 271-279
6. -DiFrancesco,D., Noma,A. & Trautwein,W. (1980) Separation of current induced by potassium accumulation from acetylcholine-induced relaxation current in the rabbit SA node. **Pflügers Arch.** 387, 83-90
7. -Brown,H.F., DiFrancesco,D., Noble,D. & Noble,S.J. (1980) The contribution of potassium accumulation to outward currents in frog atrium. **J.Physiol.** 306, 127-149
8. -DiFrancesco,D. & Noble,D. (1980) The time course of potassium current following potassium accumulation: analytical solution using a linear approximation. **J.Physiol.** 306, 151-173
9. -Brown,H.F. & DiFrancesco,D. (1980) Voltage-clamp investigations of membrane currents underlying pacemaker activity in rabbit sino-atrial node. **J.Physiol.** 308, 331-351
10. -DiFrancesco,D. & Ojeda,C. (1980) Properties of the current  $i_f$  in the sinoatrial node of the rabbit compared with those of the current  $i_{K2}$  in Purkinje fibres. **J.Physiol.** 308, 353-367
11. -DiFrancesco,D. (1981a) A new interpretation of the pacemaker current  $i_{K2}$  in calf Purkinje fibres. **J.Physiol.** 314, 359-376
12. -DiFrancesco,D. (1981b) A study of the ionic nature of the pacemaker current in calf Purkinje fibres. **J.Physiol.** 314, 377-393
13. -DiFrancesco,D. (1982) Block and activation of the pacemaker  $i_f$  channel in calf Purkinje fibres: effects of potassium, caesium and rubidium. **J.Physiol.** 329, 485-507
14. -DiFrancesco,D. & Ferroni,A. (1983) Delayed activation of the cardiac pacemaker current and its dependence on conditioning pre- hyperpolarization. **Pflügers Arch.** 396, 265-276
15. -DiFrancesco,D. (1984) Characterization of the pacemaker ( $i_f$ ) current kinetics in calf Purkinje fibres. **J.Physiol.** 348, 341-367
16. -DiFrancesco,D. & Ferroni,A. & Visentin,S. (1984) Barium-induced blockade of the inward rectifier in calf Purkinje fibres. **Pflügers Arch.** 402, 446-453
17. -DiFrancesco,D. & Noble,D. (1985) A model of cardiac electrical activity incorporating ionic pumps and concentration changes. **Phil. Trans. R. Soc. Lond. B** 307, 353-398
18. -DiFrancesco,D., Ferroni,A., Visentin,S. & Zaza,A. (1985) Cadmium- induced blockade of the cardiac fast Na channels in calf Purkinje fibres. **Proc. R. Soc. Lond. B** 223, 475-484
19. -DiFrancesco,D. Ferroni,A., Mazzanti,M. & Tromba,C. (1986) Properties of the hyperpolarizing-activated current ( $i_f$ ) in cells isolated from the rabbit sino-atrial node. **J. Physiol.** 377, 61-88
20. -DiFrancesco,D. (1986) Characterization of single pacemaker channels in cardiac sino-atrial node cells. **Nature** 324, 470-473
21. -DiFrancesco,D. & Tromba, C. (1987) Acetylcholine inhibits activation of the cardiac hyperpolarizing-activated current,  $i_f$ . **Pflügers Arch.** 410, 139-142
22. -DiFrancesco,D. & Tromba,C. (1988a) Inhibition of the hyperpolarizing -activated current,  $i_f$ , induced by acetylcholine in rabbit sino-atrial node myocytes. **J. Physiol.** 405, 477-491
23. -DiFrancesco,D. & Tromba,C. (1988b) Muscarinic control of the hyperpolarizing-activated current  $i_f$  in rabbit sino-atrial node myocytes. **J. Physiol.** 405, 493-510

24. -Mazzanti,M. & DiFrancesco,D. (1989) Intracellular Ca modulates K-inward rectification in cardiac myocytes. **Pflügers Arch.** 413, 322-324
25. -DiFrancesco,D., Ducouret,P. & Robinson,R.B. (1989) Muscarinic modulation of cardiac rate at low acetylcholine concentrations. **Science**, 243, 669-671
26. -Cohen,I.S., DiFrancesco,D., Mulrine,N.K. & Pennefather,P. (1989) Internal and external K<sup>+</sup> affect the gating of the inward rectifier in cardiac Purkinje myocytes. **Biophys. J.**, 55, 197-202
27. -Chang,F., Gao,J., Tromba,C., Cohen,I.S. & DiFrancesco,D. (1990) Acetylcholine reverses the effects of  $\beta$ -agonists on the pacemaker current in canine Purkinje fibres but has no direct action. A difference between primary and secondary pacemakers. **Circulation Res.** 66, 633-636
28. -Visentin,S. & Zaza,A., Tromba, C., Ferroni,A. & DiFrancesco,D. (1990) Sodium current block caused by cations of group 2b in calf Purkinje fibres and in guinea-pig ventricular myocytes. **Pflügers Arch.** 517, 213-222
29. -DiFrancesco,D. (1991) The contribution of the “pacemaker” current ( $i_f$ ) to the generation of spontaneous activity in rabbit sino-atrial node myocytes. **J. Physiol.** 434, 23-40
30. -DiFrancesco,D., Porciatti,F., Janigro,D., Maccaferri,G., Mangoni,M., Tritella,T., Chang,F. & Cohen,I.S. (1991) Block of the cardiac pacemaker current ( $i_f$ ) in rabbit SA node and in the canine Purkinje fibres by 9-amino-1,2,3,4-Tetrahydroacridine. **Pflügers Arch.** 417, 611-615
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