

**Aproximació molecular a l'estudi dels primats:  
Evolució dels gens *RPS4Y* i  
aplicació d'SNPs en conservació**

Memòria presentada per  
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Per optar al grau de  
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# CONCLUSIONS



Dels resultats obtinguts en aquesta tesi es pot concloure que:

1. La tècnica d'Amplificació per Desplaçament Múltiple (MDA) aplicada sobre DNA extret de mostres de semen de macaco recol·lectades de manera no invasiva dona productes amplificats adequats per realitzar anàlisis genètiques. Les seqüències de regió control del DNA mitocondrial obtingudes a partir dels productes d'MDA són de la mateixa qualitat que les obtingudes amb les mostres de DNA originals, tot i que en general s'obtenen seqüències més curtes.
2. La tècnica del DHPLC és útil pel descobriment d'SNPs en espècies no model, de les que no es disposa d'informació de seqüències, i especialment en regions de baixa variabilitat genètica, perquè permet reduir els esforços de seqüenciació.
3. La tecnologia desenvolupada en humans pot ser transferida a l'estudi d'altres espècies. El *microarray* de miniseqüència desenvolupat en aquesta tesi permet l'estudi simultani del llinatge matern i patern en el ximpanzé en un sol conjunt d'experiments gràcies a la informació que aporta el genotipatge d'SNPs de gens mitocondrials i d'introns de gens del cromosoma Y.
4. El *microarray* desenvolupat permet fer testos de paternitat i obtenir llinatges genealògics en poblacions captives de ximpanzé de manera fiable i eficaç. Es tracta, doncs, d'una eina útil en conservació biològica per a la gestió de poblacions captives.
5. El *microarray* desenvolupat pot ser aplicat a l'estudi de poblacions salvatges de ximpanzé. Els resultats d'estructura poblacional i història demogràfica que aporten els SNPs mitocondrials coincideixen amb els obtinguts amb les seqüències de la regió control del DNA mitocondrial i amb els generats a partir de microsatèl·lits. Actualment aquesta eina aporta informació complementària a l'obtinguda amb marcadors microsatèl·lit.
6. El *microarray* podria ser optimitzat incrementant el número d'SNPs i afegint SNPs de regions autosòmiques de manera que aportés informació de totes les regions genòmiques. Aquests avenços podrien convertir aquest sistema en una eina de gran

suport en l'estudi i conservació de poblacions de ximpanzé, fins al punt que podria desplaçar altres tècniques i marcadors.

7. Tots els infraordres de primat presenten, com a mínim, una còpia del gen *RPS4* en el cromosoma Y, tal com s'havia postulat anteriorment.

8. La duplicació del gen *RPS4Y* per donar la segona còpia del cromosoma Y, el gen *RPS4Y2*, es va produir entre la divergència de les mones del Nou Món i de les mones del Vell Món. S'ha estimat que l'esdeveniment de duplicació va tenir lloc fa uns 35 milions d'anys.

9. La selecció positiva ha actuat en l'evolució del gen *RPS4Y2* en el llinatge humà. Aquest és el primer estudi que identifica de manera inambigua l'acció de la selecció positiva en una proteïna ribosomal. Les substitucions aminoacídiques afectades per la selecció involucren els tres dominis de la proteïna, però el canvi en el domini KOW és especialment interessant perquè modifica l'únic aminoàcid invariable d'aquest domini i pot haver comportat conseqüències dràstiques en la funció proteica.

10. La hipòtesi més plausible per a la preservació de la primera còpia del gen *RPS4* en el cromosoma Y, *RPS4Y1*, és per compensació de la dosi proteica en el complex ribosomal dels mascles de primat. La supervivència del gen *RPS4Y2*, en canvi, sembla que respondria a un procés d'especialització funcional o de neofuncionalització, possiblement cap a una funció relacionada amb l'espermatogènesi, com a mínim en el llinatge humà.

# REFERÈNCIES



- Aitken N, Smith S, Schwarz C, Morin PA (2004) Single nucleotide polymorphism (SNP) discovery in mammals: a targeted-gene approach. *Molecular Ecology* **13**, 1423-1431.
- Aitken RJ, Graves JAM (2002) Human spermatozoa: The future of sex. *Nature* **415**, 963-963.
- Ali S, Hasnain SE (2003) Genomics of the human Y-chromosome - 1. Association with male infertility. *Gene* **321**, 25-37.
- Arakawa Y, Nishida-Umehara C, Matsuda Y, Sutou S, Suzuki H (2002) X-chromosomal localization of mammalian Y-linked genes in two XO species of the Ryukyu spiny rat. *Cytogenetic And Genome Research* **99**, 303-309.
- Archidiacono N, Storlazzi CT, Spalluto C, *et al.* (1998) Evolution of chromosome Y in primates. *Chromosoma* **107**, 241-246.
- Armour JAL, Alegre, S.A., Miles, S., Williams, L.J., Badge, R.M. (1999) Minisatellites and mutation processes in tandemly repetitive DNA. In: *Microsatellites: Evolution and Applications*. (ed. Goldstein DB, Schlötterer, C.), pp. 24-33. Oxford University Press, Oxford.
- Arntz Y, Seelig JD, Lang HP, *et al.* (2003) Label-free protein assay based on a nanomechanical cantilever array. *Nanotechnology* **14**, 86-90.
- Ayub Q, Mohyuddin, A., Qamar, R., Mazhar, K., Zerjal, T., Mehdi, S.Q., Tyler-Smith, C. (2000) Identification and characterisation of novel human Y-chromosomal microsatellites from sequence database information. *Nucleic Acids Research* **28**, e8.
- Bachtrog D (2005) Sex chromosome evolution: Molecular aspects of Y-chromosome degeneration in *Drosophila*. *Genome Research* **15**, 1393-1401.
- Bachtrog D (2006) A dynamic view of sex chromosome evolution. *Current Opinion In Genetics & Development* **16**, 578-585.
- Bachtrog D, Charlesworth, B. (2001) Towards a complete sequence of the human Y chromosome. *Genome Biology* **2**, Reviews1016.1011-1016.1015.
- Balmford A, Bruner A, Cooper P, *et al.* (2002) Ecology - Economic reasons for conserving wild nature. *Science* **297**, 950-953.
- Balvanera P, Daily GC, Ehrlich PR, *et al.* (2001) Conserving biodiversity and ecosystem services. *Science* **291**, 2047-2047.
- Batley J, Hayes PK (2003) Development of high throughput single nucleotide polymorphism genotyping for the analysis of *Nodularia* (Cyanobacteria) population genetics. *Journal Of Phycology* **39**, 248-252.
- Belfiore NM, Hoffman FG, Baker RJ, Dewoody JA (2003) The use of nuclear and mitochondrial single nucleotide polymorphisms to identify cryptic species. *Molecular Ecology* **12**, 2011-2017.
- Bellinger MR, Johnson JA, Toepfer J, Dunn P (2003) Loss of genetic variation in Greater Prairie Chickens following a population bottleneck in Wisconsin, USA. *Conservation Biology* **17**, 717-724.
- Bensasson D, Zhang DX, Hartl DL, Hewitt GM (2001) Mitochondrial pseudogenes: evolution's misplaced witnesses. *Trends In Ecology & Evolution* **16**, 314-321.



- Bensch S, Akesson S, Irwin DE (2002) The use of AFLP to find an informative SNP: genetic differences across a migratory divide in willow warblers. *Molecular Ecology* **11**, 2359-2366.
- Bergen AW, Pratt M, Mehlman PT, Goldman D (1998) Evolution of *RPS4Y*. *Molecular Biology And Evolution* **15**, 1412-1419.
- Bermejo M, Rodríguez-Tejreiro, J. D., Illera, G., Barroso, A., Vilà, C., Walsh, P. D. (2005) Ebola Outbreak Killed 5000 Gorillas. *Science* **314**, 1564.
- Bielawski JP, Yang ZH (2001) Positive and negative selection in the *DAZ* gene family. *Molecular Biology and Evolution* **18**, 523-529.
- Blagosklonova O, Fellmann F, Clavequin MC, Roux C, Bresson JL (2000) AZFa deletions in Sertoli cell-only syndrome: a retrospective study. *Molecular Human Reproduction* **6**, 795-799.
- Boesch C (1996) Social grouping in Tai chimpanzees. In: *Great ape societies* (ed. McGrew WC, Marchant, L.F., Nishida, T.), pp. 101-113. Cambridge University Press, Cambridge.
- Bowen-Jones E, Pendry S (1999) The threat to primates and other mammals from the bushmeat trade in Africa, and how this threat could be diminished. *Oryx* **33**, 233-246.
- Brandt O, Feldner J, Stephan A, et al. (2003) PNA microarrays for hybridisation of unlabelled DNA samples. *Nucleic Acids Research* **31**.
- Bridges CB (1936) The "Bar" gene, a duplication. *Science* **83**, 210-211.
- Brion M, Salas A, Gonzalez-Neira A, Lareu MV, Carracedo A (2003) Insights into Iberian population origins through the construction of highly informative Y-chromosome haplotypes using biallelic markers, STRs, and the MSY1 minisatellite. *American Journal Of Physical Anthropology* **122**, 147-161.
- Brockelman WY, Reichard, U., Treesucon, U., Raemaekers, J.J. (1998) Dispersal, pair formation and social structure in gibbons (*Hylobates lar*). *Behavioral Ecology and Sociobiology* **42**, 329-339.
- Brooks R, Williamson J, Hensley A, et al. (2003) Buccal cells as a source of DNA for comparative animal genomic analysis. *Biotechnology Letters* **25**, 451-454.
- Brumfield RT, Beerli P, Nickerson DA, Edwards SV (2003) The utility of single nucleotide polymorphisms in inferences of population history. *Trends In Ecology & Evolution* **18**, 249-256.
- Burrows W, Ryder OA (1997) Y-chromosome variation in great apes. *Nature* **385**, 125-126.
- Butler JM (2003) Recent Developments in Y-Short Tandem Repeat and Y-Single Nucleotide Polymorphism Analysis. *Forensic Science Review* **15**, 92-111.
- Carter RE (2000) General molecular biology. In: *Molecular Methods in Ecology* (ed. Baker AJ). Blackwell Science, Oxford.
- Carvalho AB (2002) Origin and evolution of the *Drosophila* Y chromosome. *Current Opinion In Genetics & Development* **12**, 664-668.
- Carvalho AB, Clark AG (2005) Y chromosome of *D. pseudoobscura* is not homologous to the ancestral *Drosophila* Y. *Science* **307**, 108-110.

- Casanova M, Leroy P, Boucekine C, *et al.* (1985) A human Y-linked DNA polymorphism and its potential for estimating genetic and evolutionary distance. *Science* **230**, 1403-1406.
- Caughley G (1994) Directions in Conservation Biology. *Journal Of Animal Ecology* **63**, 215-244.
- Clark NL, Swanson WJ (2005) Pervasive adaptive evolution in primate seminal proteins. *Plos Genetics* **1**, 335-342.
- Conant GC, Wagner A (2002) GenomeHistory: a software tool and its application to fully sequenced genomes. *Nucleic Acids Research* **30**, 3378-3386.
- Constable JL, Ashley MV, Goodall J, Pusey AE (2001) Noninvasive paternity assignment in Gombe chimpanzees. *Molecular Ecology* **10**, 1279-1300.
- Corach D, Risso LF, Marino M, Penacino G, Sala A (2001) Routine Y-STR typing in forensic casework. *Forensic Science International* **118**, 131-135.
- Cotton RGH (1997) Slowly but surely towards better scanning for mutations. *Trends In Genetics* **13**, 43-46.
- Chakraborty R, Stivers DN, Su B, Zhong YX, Budowle B (1999) The utility of short tandem repeat loci beyond human identification: Implications for development of new DNA typing systems. *Electrophoresis* **20**, 1682-1696.
- Chapman CA, Peres CA (2001) Primate conservation in the new millennium: The role of scientists. *Evolutionary Anthropology* **10**, 16-33.
- Chapman CA, Wrangham RW, Chapman LJ (1995) Ecological constraints on group-size - An analysis of Spider Monkey and Chimpanzee subgroups. *Behavioral Ecology And Sociobiology* **36**, 59-70.
- Charlesworth B (1996) The evolution of chromosomal sex determination and dosage compensation. *Current Biology* **6**, 149-162.
- Charlesworth B, Charlesworth D (1997) Rapid fixation of deleterious alleles can be caused by Muller's ratchet. *Genetical Research* **70**, 63-73.
- Charlesworth B, Charlesworth D (2000) The degeneration of Y chromosomes. *Philosophical Transactions Of The Royal Society Of London Series B-Biological Sciences* **355**, 1563-1572.
- Darwin C (1859) *On the Origin of Species by Means of Natural Selection* P.F. Collier & Son, New York.
- de Knijff P (2000) Messages through bottlenecks: On the combined use of slow and fast evolving polymorphic markers on the human Y chromosome. *American Journal Of Human Genetics* **67**, 1055-1061.
- de Knijff P (2006) The Human Y chromosome is not dead (yet). *Heredity* **97**, 377-378.
- Dean FB, Hosono S, Fang LH, *et al.* (2002) Comprehensive human genome amplification using multiple displacement amplification. *Proceedings Of The National Academy Of Sciences Of The United States Of America* **99**, 5261-5266.
- Deinard AS, Kidd K (2000) Identifying conservation units within captive chimpanzee populations. *American Journal Of Physical Anthropology* **111**, 25-44.

- Delibes M (2004) La acción humana y la crisis de la biodiversidad. In: *Los retos medioambientales del siglo XXI* (ed. Gomendio M), pp. 23-38. Fundación BBVA, Bilbao.
- Delibes M (2005) ¿Qué es lo que pretendemos conservar y qué significa en ese contexto recuperar especies amenazadas? In: *Al borde de la extinción: una visión integral de la recuperación de fauna amenazada en España* (ed. Jiménez I, Delibes, M.), pp. 17-28. EVREN (Evaluación de Recursos Naturales), Valencia.
- DeSalle R (2005) Conservation genetics - Genetics at the brink of extinction. *Heredity* **94**, 386-387.
- DeSalle R (2006) Species discovery versus species identification in DNA barcoding efforts: Response to Rubinoff. *Conservation Biology* **20**, 1545-1547.
- DeSalle R, Amato G (2004) The expansion of conservation genetics. *Nature Reviews Genetics* **5**, 702-712.
- Disteche CM (1997) The great escape - Invited editorial. *American Journal Of Human Genetics* **60**, 1312-1315.
- Dixon AF (1998) Sexual selection and evolution of the seminal vesicles in primates. *Folia Primatologica* **69**, 300-306.
- Dixon AF, Anderson MJ (2002) Sexual selection, seminal coagulation and copulatory plug formation in primates. *Folia Primatologica* **73**, 63-69.
- Domingo-Roura X, Marmi J, Andres O, Yamagiwa J, Terradas J (2004) Genotyping from semen of wild Japanese Macaques (*Macaca fuscata*). *American Journal Of Primatology* **62**, 31-42.
- Domingo-Roura X, Marmi J, Ferrando A, et al. (2006) Badger hair in shaving brushes comes from protected Eurasian badgers. *Biological Conservation* **128**, 425-430.
- Dorus S, Evans PD, Wyckoff GJ, Choi SS, Lahn BT (2004) Rate of molecular evolution of the seminal protein gene SEMG2 correlates with levels of female promiscuity. *Nature Genetics* **36**, 1326-1329.
- Dorus S, Gilbert SL, Forster ML, Barndt RJ, Lahn BT (2003) The CDY-related gene family: coordinated evolution in copy number, expression profile and protein sequence. *Human Molecular Genetics* **12**, 1643-1650.
- Erler A, Stoneking M, Kayser M (2004) Development of Y-chromosomal microsatellite markers for nonhuman primates. *Molecular Ecology* **13**, 2921-2930.
- Fakhrai-Rad H, Pourmand N, Ronaghi M (2002) Pyrosequencing (TM): An accurate detection platform for single nucleotide polymorphisms. *Human Mutation* **19**, 479-485.
- Fisher RA (1931) The evolution of dominance. *Biological Reviews* **6**, 345-368.
- Fitzgerald S (1989) *International Wildlife Trade: Whose business is it?* World Wildlife Fund—USA.
- Force A, Lynch M, Pickett FB, et al. (1999) Preservation of duplicate genes by complementary, degenerative mutations. *Genetics* **151**, 1531-1545.
- Frankel OH (1970) Variation, the essence of life. *Proceedings of the Linnean Society of New South Wales* **95**, 158-169.
- Frankel OH (1974) Genetic Conservation - Our Evolutionary Responsibility. *Genetics* **78**, 53-65.

- Frankham R, Ballou, J.D., Briscoe, D.A. (2002) *Introduction to Conservation Genetics* Cambridge University Press, Cambridge.
- Frantz AC, Schaul M, Pope LC, *et al.* (2004) Estimating population size by genotyping remotely plucked hair: the Eurasian badger. *Journal Of Applied Ecology* **41**, 985-995.
- Fredga K (1988) Aberrant chromosomal sex-determining mechanisms in Mammals, with special reference to species with XY-females. *Philosophical Transactions Of The Royal Society Of London Series B-Biological Sciences* **322**, 83-94.
- Gagneux P (2002) The genus *Pan*: population genetics of an endangered outgroup. *Trends In Genetics* **18**, 327-330.
- Gagneux P, Boesch C, Woodruff DS (1999) Female reproductive strategies, paternity and community structure in wild West African chimpanzees. *Animal Behaviour* **57**, 19-32.
- Gautschi B, Muller JP, Schmid B, Shykoff JA (2003) Effective number of breeders and maintenance of genetic diversity in the captive bearded vulture population. *Heredity* **91**, 9-16.
- Geerkens C, Just W, Held KR, Vogel W (1996) Ullrich-Turner syndrome is not caused by haploinsufficiency of RPS4X. *Human Genetics* **97**, 39-44.
- Gerrard DT, Filatov DA (2005) Positive and negative selection on mammalian Y chromosomes. *Molecular Biology and Evolution* **22**, 1423-1432.
- Gerry NP, Witowski NE, Day J, *et al.* (1999) Universal DNA microarray method for multiplex detection of low abundance point mutations. *Journal Of Molecular Biology* **292**, 251-262.
- Gharizadeh B, Akhras M, Nourizad N, *et al.* (2006) Methodological improvements of pyrosequencing technology. *Journal Of Biotechnology* **124**, 504-511.
- Gibbs RA, Belmont JW, Hardenbol P, *et al.* (2003) The International HapMap Project. *Nature* **426**, 789-796.
- Gläser B, Grutzner F, Willmann U, *et al.* (1998) Simian Y Chromosomes: species-specific rearrangements of *DAZ*, *RBM*, and *TSPY* versus contiguity of *PAR* and *SRY*. *Mammalian Genome* **9**, 226-231.
- Goldberg TL, Wrangham RW (1997) Genetic correlates of social behaviour in wild chimpanzees: evidence from mitochondrial DNA. *Animal Behaviour* **54**, 559-570.
- Gonder MK, Disotell TR, Oates JF (2006) New genetic evidence on the evolution of chimpanzee populations and implications for taxonomy. *International Journal Of Primatology* **27**, 1103-1127.
- Gonder MK, Oates JF, Disotell TR, *et al.* (1997) A new west African chimpanzee subspecies? *Nature* **388**, 337-337.
- Goodall J (1986) *The Chimpanzees of Gombe: Patterns of Behavior* Bellknap Press of the Harvard University Press, Boston.
- Goossens B, Funk SM, Vidal C, *et al.* (2002) Measuring genetic diversity in translocation programmes: principles and application to a chimpanzee release project. *Animal Conservation* **5**, 225-236.

- Goossens B, Graziani L, Waits LP, *et al.* (1998) Extra-pair paternity in the monogamous Alpine marmot revealed by nuclear DNA microsatellite analysis. *Behavioral Ecology And Sociobiology* **43**, 281-288.
- Graur D, Li, W. H. (1999) *Fundamentals of Molecular Evolution* Sinauer Associates Inc., Massachusetts.
- Graves JAM (2002) The rise and fall of SRY. *Trends In Genetics* **18**, 259-264.
- Graves JAM (2005) Recycling the Y chromosome. *Science* **307**, 50-51.
- Graves JAM (2006) Sex chromosome specialization and degeneration in mammals. *Cell* **124**, 901-914.
- Graves JAM, Disteché CM, Toder R (1998) Gene dosage in the evolution and function of mammalian sex chromosomes. *Cytogenetics And Cell Genetics* **80**, 94-103.
- Graves JAM, Koina E, Sanković N (2006) How the gene content of human sex chromosomes evolved. *Current Opinion In Genetics & Development* **16**, 219-224.
- Groves C (2001) *Primate taxonomy* Smithsonian Inst Pr., Washington DC.
- Grubb P, Butynski TM, Oates JF, *et al.* (2003) Assessment of the diversity of African primates. *International Journal Of Primatology* **24**, 1301-1357.
- Gu ZL, Nicolae D, Lu HHS, Li WH (2002) Rapid divergence in expression between duplicate genes inferred from microarray data. *Trends In Genetics* **18**, 609-613.
- Gusmao L, Gonzalez-Neira A, Alves C, *et al.* (2002) Chimpanzee homologous of human Y specific STRs - A comparative study and a proposal for nomenclature. *Forensic Science International* **126**, 129-136.
- Hacia JC, Sun B, Hunt N, *et al.* (1998) Strategies for mutational analysis of the large multiexon ATM gene using high-density oligonucleotide arrays. *Genome Research* **8**, 1245-1258.
- Hackstein JHP, Hochstenbach R, Hauschteck-Jungen E, Beukeboom LW (1996) Is the Y chromosome of *Drosophila* an evolved supernumerary chromosome? *Bioessays* **18**, 317-323.
- Hahn J, Lieber CM (2004) Direct ultrasensitive electrical detection of DNA and DNA sequence variations using nanowire nanosensors. *Nano Letters* **4**, 51-54.
- Haig SM, Mullins TD, Forsman ED, Trail PW, Wennerberg L (2004) Genetic identification of Spotted Owls, Barred Owls, and their hybrids: Legal implications of hybrid identity. *Conservation Biology* **18**, 1347-1357.
- Haldane JBS (1932) *The Causes of Evolution* Cornell University Press, Ithaca (NY).
- Hammer MF (1995) A recent common ancestry for Human-Y-Chromosomes. *Nature* **378**, 376-378.
- Hartl D.L. CAG (1997) *Principles of Population Genetics*, 3rd edn. Sinauer Associates Inc., Sunderland, Massachusetts.
- Harvey PH, Harcourt, A.H. (1984) Sperm competition, testis size, and breeding systems in primates. In: *Sperm Competition and the Evolution of Animal Mating Systems* (ed. Smith RL), pp. 589-600. Academic Press, New York.

- Hayakawa S, Takenaka O (1999) Urine as another potential source for template DNA in polymerase chain reaction (PCR). *American Journal Of Primatology* **48**, 299-304.
- Hebert PDN, Cywinska A, Ball SL, DeWaard JR (2003) Biological identifications through DNA barcodes. *Proceedings Of The Royal Society Of London Series B-Biological Sciences* **270**, 313-321.
- Hedrick PW, Kalinowski ST (2000) Inbreeding depression in conservation biology. *Annual Review Of Ecology And Systematics* **31**, 139-162.
- Hellborg L, Ellegren H (2003) Y chromosome conserved anchored tagged sequences (YCATS) for the analysis of mammalian male-specific DNA. *Molecular Ecology* **12**, 283-291.
- Hoheisel JD (2006) Microarray technology: beyond transcript profiling and genotype analysis. *Nature Reviews Genetics* **7**, 200-210.
- Hosken DJ, Stockley P (2004) Sexual selection and genital evolution. *Trends In Ecology & Evolution* **19**, 87-93.
- Hsu TM, Chen X, Duan S, Miller RD, Kwok PY (2001) Universal SNP genotyping assay with fluorescence polarization detection. *Biotechniques* **31**, 560-+.
- Hughes AL (1999) *Adaptive Evolution of Genes and Genomes* Oxford University Press, Oxford.
- Hughes JF, Skaletsky H, Pyntikova T, et al. (2005) Conservation of Y-linked genes during human evolution revealed by comparative sequencing in chimpanzee. *Nature* **437**, 101-104.
- Hurst LD (2001) Evolutionary genomics - Sex and the X. *Nature* **411**, 149-150.
- Hurst LD, Smith NGC (1998) The evolution of concerted evolution. *Proceedings Of The Royal Society Of London Series B-Biological Sciences* **265**, 121-127.
- Inagaki S, Yamamoto, Y., Doi, Y., Takata, T., Ishikawa, T., Yoshitome, K., Miyaishi, S., Ishizu, H. (2002) Typing of Ychromosome single nucleotide polymorphisms in a Japanese population by a multiplexed single nucleotide primer extension reaction. *Legal Medicine* **4**, 202.
- Inoue E, Inoue-Murayama, M., Takenaka, O., Nishida, T. (2007) Wild chimpanzee infant urine and saliva sampled noninvasively usable for DNA analyses. *Primates* **48**, 156-159.
- Janzen DH (2004) Now is the time. *Philosophical Transactions Of The Royal Society Of London Series B-Biological Sciences* **359**, 731-732.
- Janzen FJ, Phillips PC (2006) Exploring the evolution of environmental sex determination, especially in reptiles. *Journal Of Evolutionary Biology* **19**, 1775-1784.
- Jeffreys AJ (1979) DNA-sequence variants in the G $\gamma$ -, A $\gamma$ -,  $\delta$ - and  $\beta$ -globin genes of Man. *Cell* **18**, 1-10.
- Jegalian K, Page DC (1998) A proposed path by which genes common to mammalian X and Y chromosomes evolve to become X inactivated. *Nature* **394**, 776-780.
- Jensen-Seaman MI, Li WH (2003) Evolution of the hominoid semenogelin genes, the major proteins of ejaculated semen. *Journal Of Molecular Evolution* **57**, 261-270.
- Jobling MA, Tyler-Smith C (2000) New uses for new haplotypes - the human Y chromosome, disease and selection. *Trends In Genetics* **16**, 356-362.

- Jobling MA, Williams G, Schiebel K, *et al.* (1998) A selective difference between human Y-chromosomal DNA haplotypes. *Current Biology* **8**, 1391-1394.
- Jobs M, Howell WM, Stromqvist L, Mayr T, Brookes AJ (2003) DASH-2: Flexible, low-cost, and high-throughput SNP genotyping by dynamic allele-specific hybridization on membrane arrays. *Genome Research* **13**, 916-924.
- Jones MB, Schildhauer MP, Reichman OJ, Bowers S (2006) The new bioinformatics: Integrating ecological data from the gene to the biosphere. *Annual Review Of Ecology Evolution And Systematics* **37**, 519-544.
- Just W, Baumstark A, Hameister H, *et al.* (2002) The sex determination in *Ellobius lutescens* remains bizarre. *Cytogenetic And Genome Research* **96**, 146-153.
- Just W, Rau W, Vogel W, *et al.* (1995) Absence of *SRY* in species of the vole *Ellobius*. *Nature Genetics* **11**, 117-118.
- Kalinowski ST, Hedrick PW, Miller PS (2000) Inbreeding depression in the Speke's gazelle captive breeding program. *Conservation Biology* **14**, 1375-1384.
- Kamp C, Hirschmann P, Voss H, Huellen K, Vogt PH (2000) Two long homologous retroviral sequence blocks in proximal Yq11 cause AZFa microdeletions as a result of intrachromosomal recombination events. *Human Molecular Genetics* **9**, 2563-2572.
- Kayser M, Roewer L, Hedman M, *et al.* (2000) Characteristics and frequency of germline mutations at microsatellite loci from the human Y chromosome, as revealed by direct observation in father/son pairs. *American Journal Of Human Genetics* **66**, 1580-1588.
- Kmiec B, Woloszynska M, Janska H (2006) Heteroplasmy as a common state of mitochondrial genetic information in plants and animals. *Current Genetics* **50**, 149-159.
- Krawczak M (1999) Informativity assessment for biallelic single nucleotide polymorphisms. *Electrophoresis* **20**, 1676-1681.
- Kuroda-Kawaguchi T, Skaletsky H, Brown LG, *et al.* (2001) The AZFc region of the Y chromosome features massive palindromes and uniform recurrent deletions in infertile men. *Nature Genetics* **29**, 279-286.
- Kuroki Y, Toyoda A, Noguchi H, *et al.* (2006) Comparative analysis of chimpanzee and human Y chromosomes unveils complex evolutionary pathway. *Nature Genetics* **38**, 158-+.
- Lage JM, Leamon JH, Pejovic T, *et al.* (2003) Whole genome analysis of genetic alterations in small DNA samples using hyperbranched strand displacement amplification and array-CGH. *Genome Research* **13**, 294-307.
- Lahn BT, Page DC (1997) Functional coherence of the human Y chromosome. *Science* **278**, 675-680.
- Lahn BT, Page DC (1999) Four evolutionary strata on the human X chromosome. *Science* **286**, 964-967.
- Lande R (1988) Genetics and demography in biological conservation. *Science* **241**, 1455-1460.

- Lander ES, Linton LM, Birren B, *et al.* (2001) Initial sequencing and analysis of the human genome. *Nature* **409**, 860-921.
- Lareu M, Puente J, Sobrino B, *et al.* (2001) The use of the LightCycler for the detection of Y chromosome SNPs. *Forensic Science International* **118**, 163-168.
- Lasken RS, Egholm M (2003) Whole genome amplification: abundant supplies of DNA from precious samples or clinical specimens. *Trends In Biotechnology* **21**, 531-535.
- Li WH (1997) *Molecular Evolution* Sinauer Associates, Inc., Sunderland.
- Lindroos K, Sigurdsson S, Johansson K, Ronnblom L, Syvanen AC (2002) Multiplex SNP genotyping in pooled DNA samples by a four-colour microarray system. *Nucleic Acids Research* **30**.
- Litt M, Luty JA (1989) A hypervariable microsatellite revealed by *in vitro* amplification of a dinucleotide repeat within the cardiac-muscle actin gene. *American Journal Of Human Genetics* **44**, 397-401.
- Long M (2001) Evolution of novel genes. *Current Opinion In Genetics & Development* **11**, 673-680.
- López-Giráldez F (2006) *Oríge, evolució i aplicació en genètica de la conservació de DNA repetitiu en carnívors*, Universitat Autònoma de Barcelona.
- Lorenz JG, Jackson WE, Beck JC, Hanner R (2005) The problems and promise of DNA barcodes for species diagnosis of primate biomaterials. *Philosophical Transactions Of The Royal Society B-Biological Sciences* **360**, 1869-1877.
- Lovmar L, Syvanen AC (2006) Multiple displacement amplification to create a long-lasting source of DNA for genetic studies. *Human Mutation* **27**, 603-614.
- Luikart G, England PR, Tallmon D, Jordan S, Taberlet P (2003) The power and promise of population genomics: From genotyping to genome typing. *Nature Reviews Genetics* **4**, 981-994.
- Lynch M, Conery, J.S. (2003) The evolutionary demography of duplicate genes. *Journal of Structural and Functional Genomics* **3**, 35-44.
- Lyons LA, Laughlin TF, Copeland NG, *et al.* (1997) Comparative anchor tagged sequences (CATS) for integrative mapping of mammalian genomes. *Nature Genetics* **15**, 47-56.
- Ma NSF (1981) Chromosome evolution in the Owl Monkey, *Aotus*. *American Journal of Physical Anthropology* **54**, 293-303.
- Ma NSF, Jones TC, Thorington RW, Miller A, Morgan L (1975) Y-autosome translocation in Howler Monkey, *Alouatta palliata*. *Journal Of Medical Primatology* **4**, 299-307.
- MacDonald D, editor (2001) *The encyclopedia of mammals* Facts on File, New York.
- MacKinnon J, MacKinnon, K. (1977) The formation of a new gibbon group. *Primates* **18**, 701-708.
- Makova KD, Li WH (2002) Strong male-driven evolution of DNA sequences in humans and apes. *Nature* **416**, 624-626.
- Makridakis NM, Reichardt JKV (2001) Multiplex automated primer extension analysis: Simultaneous genotyping of several polymorphisms. *Biotechniques* **31**, 1374-1380.
- Malik I (2000) *Experiments on Animals A Vatavaran report*, New Delhi.



- Manel S, Berthier P, Luikart G (2002) Detecting wildlife poaching: Identifying the origin of individuals with Bayesian assignment tests and multilocus genotypes. *Conservation Biology* **16**, 650-659.
- Martín-Vivaldi M, Cabrero, J. (2002) Selección sexual. In: *Evolución: la base de la biología*. (ed. Soler M), pp. 235-259. Editorial Proyecto Sur, Granada.
- McCollum MA, Sherwood CC, Vinyard CJ, Lovejoy CO, Schachat F (2006) Of muscle-bound crania and human brain evolution: The story behind the MYH16 headlines. *Journal Of Human Evolution* **50**, 232-236.
- McElreavey K, Quintana-Murci L (2003) Y chromosome haplogroups: A correlation with testicular dysgenesis syndrome? *Apmis* **111**, 106-114.
- Meadows JRS, Hawken RJ, Kijas JW (2004) Nucleotide diversity on the ovine Y chromosome. *Animal Genetics* **35**, 379-385.
- Messler W, Stewart CB (1997) Episodic adaptive evolution of primate lysozymes. *Nature* **385**, 151-154.
- Miesfeld R, Krystal M, Arnheim N (1981) A member of a new repeated sequence family which is conserved throughout eukaryotic evolution is found between the human  $\delta$ -globin and  $\beta$ -globin genes. *Nucleic Acids Research* **9**, 5931-5947.
- Mikkelsen TS, Hillier LW, Eichler EE, *et al.* (2005) Initial sequence of the chimpanzee genome and comparison with the human genome. *Nature* **437**, 69-87.
- Mittermeier RA, Valladares-Pádua, C., Rylands, A.B., Eudey, A.A., Butynski, T.M., Ganzhorn, J.U., Kormos, R., Aguiar, J.M., Walker, S. (2005) Primates in Peril: The World's 25 Most Endangered Primates: 2004-2006. IUCN/SSC Primate Specialist Group (PSG), the International Primatological Society (IPS), Conservation International (CI).
- Morin PA, Luikart G, Wayne RK (2004) SNPs in ecology, evolution and conservation. *Trends In Ecology & Evolution* **19**, 208-216.
- Morin PA, Moore JJ, Chakraborty R, *et al.* (1994) Kin selection, social-structure, gene flow, and the evolution of chimpanzees. *Science* **265**, 1193-1201.
- Mudry MD, Rahn M, Gorostiaga M, *et al.* (1998) Revised karyotype of *Alouatta caraya* (Primates: Platyrrhini) based on synaptonemal complex and banding analyses. *Hereditas* **128**, 9-16.
- Muller HJ (1964) The relation of recombination to mutational advance. *Mutation Research* **1**, 2-9.
- Murphy WJ, Wilkerson AJP, Raudsepp T, *et al.* (2006) Novel gene acquisition on carnivore Y chromosomes. *Plos Genetics* **2**, 353-363.
- Nahon JL (2003) Birth of 'human-specific' genes during primate evolution. *Genetica* **118**, 193-208.
- Natanaelsson C, Oskarsson MCR, Angleby H, *et al.* (2006) Dog Y chromosomal DNA sequence: identification, sequencing and SNP discovery. *Bmc Genetics* **7**.
- Navidi W, Arnheim N, Waterman MS (1992) A multiple-tubes approach for accurate genotyping of very small DNA samples by using PCR - Statistical considerations. *American Journal Of Human Genetics* **50**, 347-359.

- Nei M, Rogozin IB, Piontkivska H (2000) Purifying selection and birth-and-death evolution in the ubiquitin gene family. *Proceedings Of The National Academy Of Sciences Of The United States Of America* **97**, 10866-10871.
- Nei M, Rooney AP (2005) Concerted and birth-and-death evolution of multigene families. *Annual Review Of Genetics* **39**, 121-152.
- Nei M, S. Kumar. (2000) *Molecular Evolution and Phylogenetics* Oxford University Press, New York.
- Nellemén C, Newton, A. (2002) The great apes- the road ahead, p. 30. UNEP, Nairobi.
- Ngo KY, Vergnaud G, Johnsson C, Lucotte G, Weissenbach J (1986) A DNA probe detecting multiple haplotypes of the human Y-chromosome. *American Journal Of Human Genetics* **38**, 407-418.
- Nicod JC, Largiadèr CR (2003) SNPs by AFLP (SBA): a rapid SNP isolation strategy for non-model organisms. *Nucleic Acids Research* **31**.
- Nielsen R, Bustamante C, Clark AG, *et al.* (2005) A scan for positively selected genes in the genomes of humans and chimpanzees. *Plos Biology* **3**, 976-985.
- Nielsen R, Yang ZH (1998) Likelihood models for detecting positively selected amino acid sites and applications to the HIV-1 envelope gene. *Genetics* **148**, 929-936.
- Nishida T, Corp N, Hamai M, *et al.* (2003) Demography, female life history, and reproductive profiles among the chimpanzees of Mahale. *American Journal Of Primatology* **59**, 99-121.
- Nowak MA, Boerlijst MC, Cooke J, Smith JM (1997) Evolution of genetic redundancy. *Nature* **388**, 167-171.
- O'Brien SJ (1994) A role for molecular-genetics in biological conservation. *Proceedings Of The National Academy Of Sciences Of The United States Of America* **91**, 5748-5755.
- O'Brien SJ, Mayr E (1991) Bureaucratic mischief - Recognizing endangered species and subspecies. *Science* **251**, 1187-1188.
- Oates JF (2006) Is the chimpanzee, *Pan troglodytes* an endangered species? It depends on what "endangered" means. *Primates* **47**, 102-112.
- Oates JF, Abedi-Lartey M, McGraw WS, Struhsaker TT, Whitesides GH (2000) Extinction of a West African red colobus monkey. *Conservation Biology* **14**, 1526-1532.
- Oefner PJ, Underhill PA (1995) Comparative DNA-sequencing by Denaturing High-Performance Liquid-Chromatography (DHPLC). *American Journal Of Human Genetics* **57**, 1547-1547.
- Ohno S (1967) *Sex Chromosomes and Sex Linked Genes* Springer-Verlag, New York.
- Ohno S (1970) *Evolution by Gene Duplication* Springer-Verlag, New York.
- Olson MV (1999) When less is more: Gene loss as an engine of evolutionary change. *American Journal Of Human Genetics* **64**, 18-23.
- Ophoff RA, Terwindt GM, Vergouwe MN, *et al.* (1996) Familial hemiplegic migraine and episodic ataxia type-2 are caused by mutations in the Ca<sup>2+</sup> channel gene *CACNL1A4*. *Cell* **87**, 543-552.

- Orr HA, Kim Y (1998) An adaptive hypothesis for the evolution of the Y chromosome. *Genetics* **150**, 1693-1698.
- Pakendorf B, Stoneking M (2005) Mitochondrial DNA and human evolution. *Annual Review Of Genomics And Human Genetics* **6**, 165-183.
- Pamilo P, Oneill RJW (1997) Evolution of the *Sry* genes. *Molecular Biology and Evolution* **14**, 49-55.
- Paracchini S, Arredi B, Chalk R, Tyler-Smith C (2002) Hierarchical high-throughput SNP genotyping of the human Y chromosome using MALDI-TOF mass spectrometry. *Nucleic Acids Research* **30**.
- Pastinen T, Kurg A, Metspalu A, Peltonen L, Syvanen AC (1997) Minisequencing: A specific tool for DNA analysis and diagnostics on oligonucleotide arrays. *Genome Research* **7**, 606-614.
- Peck JR (1994) A Ruby in the rubbish - Beneficial mutations, deleterious mutations and the evolution of sex. *Genetics* **137**, 597-606.
- Peres CA (1991) Humboldt's woolly monkeys decimated by hunting in Amazonia. *Oryx* **25**, 89-95.
- Perry GH, Tito, R.Y., Verrelli, B.C. (2007) The evolutionary history of human and chimpanzee Y-chromosome gene loss. *Molecular Biology and Evolution* **24**.
- Perry GH, Verrelli BC, Stone AC (2005) Comparative analyses reveal a complex history of molecular evolution for human MYH16. *Molecular Biology And Evolution* **22**, 379-382.
- Peter C, Brunen-Nieweler C, Cammann K, Borchers T (2004) Differentiation of animal species in food by oligonucleotide microarray hybridization. *European Food Research And Technology* **219**, 286-293.
- Petit E, Balloux F, Excoffier L (2002) Mammalian population genetics: why not Y? *Trends In Ecology & Evolution* **17**, 28-33.
- Pieczarka JC, Nagamachi CY (1988) Cytogenetic studies of *Aotus* from Eastern Amazonia - Y/Autosome rearrangement. *American Journal of Primatology* **14**, 255-263.
- Piontkivska H, Rooney AP, Nei M (2002) Purifying selection and birth-and-death evolution in the histone H4 gene family. *Molecular Biology And Evolution* **19**, 689-697.
- Prendini L, Hanner, R., DeSalle, R. (2002) Obtaining, storing and archiving specimens for molecular genetic research. In: *Techniques in Molecular Systematics and Evolution. Methods and Tools in Biosciences and Medicine* (ed. DeSalle R, Giribet, G., Wheeler, W.), pp. 176-248. Birkhauser, Basel.
- Primmer CR, Borge T, Lindell J, Saetre GP (2002) Single-nucleotide polymorphism characterization in species with limited available sequence information: high nucleotide diversity revealed in the avian genome. *Molecular Ecology* **11**, 603-612.
- Quintana-Murci L, Krausz, C., McElreavey, K. (2001) The human Y chromosome: function, evolution and disease. *Forensic Science International* **118**, 169-181.

- Quintana-Murci T, Jamain S, Fellous M (2001) The origin and evolution of mammalian sex chromosomes. *Comptes Rendus De L Academie Des Sciences Serie Iii-Sciences De La Vie-Life Sciences* **324**, 1-11.
- Raitio M, Lindroos K, Laukkanen M, *et al.* (2001) Y-chromosomal SNPs in Finno-Ugric-speaking populations analyzed by minisequencing on microarrays. *Genome Research* **11**, 471-482.
- Rao E, Weiss B, Fukami M, *et al.* (1997) Pseudoautosomal deletions encompassing a novel homeobox gene cause growth failure in idiopathic short stature and Turner syndrome. *Nature Genetics* **16**, 54-63.
- Rastogi S, Liberles DA (2005) Subfunctionalization of duplicated genes as a transition state to neofunctionalization. *Bmc Evolutionary Biology* **5**.
- Refisch J, Kone I (2005) Market hunting in the Tai Region, Cote d'Ivoire and implications for monkey populations. *International Journal Of Primatology* **26**, 621-629.
- Rice WR (1987a) The accumulation of sexually antagonistic genes as a selective agent promoting the evolution of reduced recombination between primitive sex-chromosomes. *Evolution* **41**, 911-914.
- Rice WR (1987b) Genetic hitchhiking and the evolution of reduced genetic-activity of the Y-sex chromosome. *Genetics* **116**, 161-167.
- Robbins MM (1995) A demographic-analysis of male life-history and social-structure of mountain gorillas. *Behaviour* **132**, 21-47.
- Rogaev EI, Moliaka YK, Malyarchuk BA, *et al.* (2006) Complete mitochondrial genome and phylogeny of Pleistocene mammoth *Mammuthus primigenius*. *Plos Biology* **4**, 403-410.
- Roldan ERS, Gomendio M (1999) The Y chromosome as a battle ground for sexual selection. *Trends in Ecology & Evolution* **14**, 58-62.
- Rondinini C, Chiozza F, Boitani L (2006) High human density in the irreplaceable sites for African vertebrates conservation. *Biological Conservation* **133**, 358-363.
- Rönn AC, Andres O, Bruford MW, *et al.* (2006) Multiple displacement amplification for generating an unlimited source of DNA for genotyping in nonhuman primate species. *International Journal Of Primatology* **27**, 1145-1169.
- Ronning SB, Rudi K, Berdal KG, Holst-Jensen A (2005) Differentiation of important and closely related cereal plant species (Poaceae) in food by hybridization to an oligonucleotide array. *Journal Of Agricultural And Food Chemistry* **53**, 8874-8880.
- Rook MS, Delach SM, Deyneko G, Worlock A, Wolfe JL (2004) Whole genome amplification of DNA from laser capture-microdissected tissue for high-throughput single nucleotide polymorphism and short tandem repeat genotyping. *American Journal Of Pathology* **164**, 23-33.
- Rosenbaum HC, Egan MG, Clapham PJ, *et al.* (2000) Utility of North Atlantic right whale museum specimens for assessing changes in genetic diversity. *Conservation Biology* **14**, 1837-1842.

- Rouquier S, Blancher A, Giorgi D (2000) The olfactory receptor gene repertoire in primates and mouse: Evidence for reduction of the functional fraction in primates. *Proceedings Of The National Academy Of Sciences Of The United States Of America* **97**, 2870-2874.
- Rowe R, Sharma, N., Browder, J. (1992) Deforestation: problems, causes, and concerns. In: *Managing the world's forests: looking for balance between conservation and development* (ed. Sharma NP), pp. 33-45. Kendall/Hunt, Dubuque.
- Rozen S, Skaletsky H, Marszalek JD, *et al.* (2003) Abundant gene conversion between arms of palindromes in human and ape Y chromosomes. *Nature* **423**, 873-876.
- Rozen S, Warren, W.C., Weinstock, G., O'Brien, S.J., Gibbs R.A., Wilson R.K., Page D.C. (2006) Sequencing and annotating new mammalian Y chromosomes. *A White Paper Proposal*.
- Rubenstein K (2003) Commercial aspects of microarray technology. *Biotechniques*, 52-54.
- Rubinoff D (2006) Utility of mitochondrial DNA barcodes in species conservation. *Conservation Biology* **20**, 1026-1033.
- Ryder OA (1986) Species conservation and systematics - The dilemma of subspecies. *Trends In Ecology & Evolution* **1**, 9-10.
- Ryder OA (2005) Conservation genomics: applying whole genome studies to species conservation efforts. *Cytogenetic And Genome Research* **108**, 6-15.
- Sakura O (1994) Factors affecting party size and composition of chimpanzees (*Pan troglodytes verus*) at Bossou, Guinea. *International Journal Of Primatology* **15**, 167-183.
- Samonte RV, Eichler EE (2002) Segmental duplications and the evolution of the primate genome. *Nature Reviews Genetics* **3**, 65-72.
- Sbisà E, Tanzariello F, Reyes A, Pesole G, Saccone C (1997) Mammalian mitochondrial D-loop region structural analysis: identification of new conserved sequences and their functional and evolutionary implications. *Gene* **205**, 125-140.
- Schlötterer C (2000a) Evolutionary dynamics of microsatellite DNA. *Chromosoma* **109**, 365-371.
- Schlötterer C (2000b) Microsatellite analysis indicates genetic differentiation of the neo-sex chromosomes in *Drosophila americana americana*. *Heredity* **85**, 610-616.
- Schlötterer C (2004) The evolution of molecular markers - just a matter of fashion? *Nature Reviews Genetics* **5**, 63-69.
- Schwartz MK, Luikart G, Waples RS (2007) Genetic monitoring as a promising tool for conservation and management. *Trends In Ecology & Evolution* **22**, 25-33.
- Seddon JM, Parker HG, Ostrander EA, Ellegren H (2005) SNPs in ecological and conservation studies: a test in the Scandinavian wolf population. *Molecular Ecology* **14**, 503-511.
- Serebrovsky AS (1938) Genes *scute* and *achaete* in *Drosophila melanogaster* and a hypothesis of gene divergency. *C. R. Acad. Sci. URSS* **19**, 77-81.
- Shaffer ML (1981) Minimum population sizes for species conservation. *Bioscience* **31**, 131-134.

- Shoemaker DD, Lashkari DA, Morris D, Mittmann M, Davis RW (1996) Quantitative phenotypic analysis of yeast deletion mutants using a highly parallel molecular bar-coding strategy. *Nature Genetics* **14**, 450-456.
- Shoshani J, Groves CP, Simons EL, Gunnell GF (1996) Primate phylogeny: Morphological vs molecular results. *Molecular Phylogenetics And Evolution* **5**, 102-154.
- Sinclair AH, Berta P, Palmer MS, *et al.* (1990) A gene from the human sex-determining region encodes a protein with homology to a conserved DNA-binding motif. *Nature* **346**, 240-244.
- Singer-Sam J, Tanguay, R., Riggs, A.D. (1989) Use of Chelex to improve PCR signal from a small number of cells. *Amplifications: A Forum for PCR users* **3**, 11.
- Singer M, Berg, P. (1993) *Genes y Genomas* Omega, Barcelona.
- Skaletsky H, Kuroda-Kawaguchi T, Minx PJ, *et al.* (2003) The male-specific region of the human Y chromosome is a mosaic of discrete sequence classes. *Nature* **423**, 825-U822.
- Smit AFA, R. H, Green P RepeatMasker Web Server.
- Smith GP (1976) Evolution of repeated DNA sequences by unequal crossover. *Science* **191**, 528-535.
- Sorensen KJ, Turteltaub K, Vrankovich G, Williams J, Christian AT (2004) Whole-genome amplification of DNA from residual cells left by incidental contact. *Analytical Biochemistry* **324**, 312-314.
- Soulé ME, Wilcox, B.A. (1980) *Conservation Biology: An evolutionary-ecological perspective* Sinauer, Sunderland.
- Spielman D, Brook BW, Frankham R (2004) Most species are not driven to extinction before genetic factors impact them. *Proceedings Of The National Academy Of Sciences Of The United States Of America* **101**, 15261-15264.
- Stedman HH, Kozyak BW, Nelson A, *et al.* (2004) Myosin gene mutation correlates with anatomical changes in the human lineage. *Nature* **428**, 415-418.
- Stephens JC, Schneider JA, Tanguay DA, *et al.* (2001) Haplotype variation and linkage disequilibrium in 313 human genes. *Science* **293**, 489-493.
- Stern C (1957) Problem Of Complete Y-Linkage In Man. *American Journal Of Human Genetics* **9**, 147-166.
- Stone AC, Griffiths RC, Zegura SL, Hammer MF (2002) High levels of Y-chromosome nucleotide diversity in the genus *Pan*. *Proceedings Of The National Academy Of Sciences Of The United States Of America* **99**, 43-48.
- Sugiyama Y, Kawamoto S, Takenaka O, Kumazaki K, Miwa N (1993) Paternity discrimination and intergroup relationships of chimpanzees at Bossou. *Primates* **34**, 545-552.
- Sun C, Sklaetsky H, Birren B, *et al.* (1999) An azoospermic man with a de novo point mutation in the Y-chromosomal gene USP9Y. *Nature Genetics* **23**, 429-432.
- Sundqvist AK, Ellegren H, Olivier M, Vila C (2001) Y chromosome haplotyping in Scandinavian wolves (*Canis lupus*) based on microsatellite markers. *Molecular Ecology* **10**, 1959-1966.

- Suzuki Y, Gojobori T (1999) A method for detecting positive selection at single amino acid sites. *Molecular Biology And Evolution* **16**, 1315-1328.
- Sykes B (2003) *Adam's Curse: A Story of Sex, Genetics, and the Extinction of Men*. Bantam Press, London.
- Syvänen AC (2001) Accessing genetic variation: Genotyping single nucleotide polymorphisms. *Nature Reviews Genetics* **2**, 930-942.
- Taberlet P, Camarra JJ, Griffin S, *et al.* (1997) Noninvasive genetic tracking of the endangered Pyrenean brown bear population. *Molecular Ecology* **6**, 869-876.
- Taberlet P, Griffin S, Goossens B, *et al.* (1996) Reliable genotyping of samples with very low DNA quantities using PCR. *Nucleic Acids Research* **24**, 3189-3194.
- Taberlet P, Waits LP, Luikart G (1999) Noninvasive genetic sampling: look before you leap. *Trends In Ecology & Evolution* **14**, 323-327.
- Taylor JD, Briley D, Nguyen Q, *et al.* (2001) Flow cytometric platform for high-throughput single nucleotide polymorphism analysis. *Biotechniques* **30**, 661-+.
- Telenius H, Carter NP, Bebb CE, *et al.* (1992) Degenerate oligonucleotide-primed PCR - General amplification of target DNA by a single degenerate primer. *Genomics* **13**, 718-725.
- Tyler-Smith C, Howe K, Santos FR (2006) The rise and fall of the ape Y chromosome? *Nature Genetics* **38**, 141-143.
- Underhill PA, Jin L, Lin AA, *et al.* (1997) Detection of numerous Y chromosome biallelic polymorphisms by denaturing high-performance liquid chromatography. *Genome Research* **7**, 996-1005.
- Underhill PA, Jin L, Zemans R, Oefner PJ, CavalliSforza LL (1996) A pre-Columbian Y chromosome-specific transition and its implications for human evolutionary history. *Proceedings Of The National Academy Of Sciences Of The United States Of America* **93**, 196-200.
- Underhill PA, Shen PD, Lin AA, *et al.* (2000) Y chromosome sequence variation and the history of human populations. *Nature Genetics* **26**, 358-361.
- Urata H, Ogura E, Shinohara K, Ueda Y, Akagi M (1992) Synthesis and properties of mirror-image DNA. *Nucleic Acids Research* **20**, 3325-3332.
- Valière N, Taberlet P (2000) Urine collected in the field as a source of DNA for species and individual identification. *Molecular Ecology* **9**, 2150-2152.
- van Schaik CP, van Hooff J.A.R.A.M. (1996) Toward an understanding of the orangutan's social system. In: *Great ape societies* (ed. McGrew WC, Marchant, L.F., Nishida, T.), pp. 3-15. Cambridge University Press, Cambridge.
- Venter JC, Adams MD, Myers EW, *et al.* (2001) The sequence of the human genome. *Science* **291**, 1304-+.
- Vigilant L, Hofreiter M, Siedel H, Boesch C (2001) Paternity and relatedness in wild chimpanzee communities. *Proceedings Of The National Academy Of Sciences Of The United States Of America* **98**, 12890-12895.

- Vignal A, Milan D, SanCristobal M, Eggen A (2002) A review on SNP and other types of molecular markers and their use in animal genetics. *Genetics Selection Evolution* **34**, 275-305.
- Vogel W, Jainta S, Rau W, *et al.* (1998) Sex determination in *Ellobius lutescens*: The story of an enigma. *Cytogenetics And Cell Genetics* **80**, 214-221.
- Vogt PH, Edelmann A, Kirsch S, *et al.* (1996) Human Y chromosome azoospermia factors (AZF) mapped to different subregions in Yq11. *Human Molecular Genetics* **5**, 933-943.
- Wan QH, Fang SG (2003) Application of species-specific polymerase chain reaction in the forensic identification of tiger species. *Forensic Science International* **131**, 75-78.
- Wang DG, Fan JB, Siao CJ, *et al.* (1998) Large-scale identification, mapping, and genotyping of single-nucleotide polymorphisms in the human genome. *Science* **280**, 1077-1082.
- Wang G, Maher E, Brennan C, *et al.* (2004) DNA amplification method tolerant to sample degradation. *Genome Research* **14**, 2357-2366.
- Wang XX, Grus WE, Zhang JZ (2006) Gene losses during human origins. *Plos Biology* **4**, 366-377.
- Whiten A, Goodall J, McGrew WC, *et al.* (1999) Cultures in chimpanzees. *Nature* **399**, 682-685.
- Whiten A, Goodall J, McGrew WC, *et al.* (2001) Charting cultural variation in chimpanzees. *Behaviour* **138**, 1481-1516.
- Woodruff DS (2001) Declines of biomes and biotas and the future of evolution. *Proceedings Of The National Academy Of Sciences Of The United States Of America* **98**, 5471-5476.
- Xiao WZ, Oefner PJ (2001) Denaturing high-performance liquid chromatography: A review. *Human Mutation* **17**, 439-474.
- Xu XF, Arnason U (1996) The mitochondrial DNA molecule of sumatran orangutan and a molecular proposal for two (Bornean and Sumatran) species of orangutan. *Journal Of Molecular Evolution* **43**, 431-437.
- Xue YL, Daly A, Yngvadottir B, *et al.* (2006) Spread of an inactive form of caspase-12 in humans is due to recent positive selection. *American Journal Of Human Genetics* **78**, 659-670.
- Yan P, Wu XB, Shi Y, *et al.* (2005) Identification of Chinese alligators (*Alligator sinensis*) meat by diagnostic PCR of the mitochondrial cytochrome b gene. *Biological Conservation* **121**, 45-51.
- Yang DY, Eng B, Wayne JS, Dudar JC, Saunders SR (1998) Technical note: Improved DNA extraction from ancient bones using silica-based spin columns. *American Journal Of Physical Anthropology* **105**, 539-543.
- Yang ZH (1997) PAML: a program package for phylogenetic analysis by maximum likelihood. *Computer Applications In The Biosciences* **13**, 555-556.
- Yang ZH, Nielsen R (2002) Codon-substitution models for detecting molecular adaptation at individual sites along specific lineages. *Molecular Biology And Evolution* **19**, 908-917.
- Yang ZH, Nielsen R, Goldman N, Pedersen AMK (2000) Codon-substitution models for heterogeneous selection pressure at amino acid sites. *Genetics* **155**, 431-449.



- Yoder AD (1994) Relative position of the Cheirogaleidae in Strepsirhine phylogeny - A comparison of morphological and molecular methods and results. *American Journal Of Physical Anthropology* **94**, 25-46.
- Yokoyama S, Yokoyama R (1989) Molecular evolution of human visual pigment genes. *Molecular Biology And Evolution* **6**, 186-197.
- Yu M, Irwin DM (1996) Evolution of stomach lysozyme: The pig lysozyme gene. *Molecular Phylogenetics And Evolution* **5**, 298-308.
- Zhang JZ (2003) Evolution by gene duplication: an update. *Trends In Ecology & Evolution* **18**, 292-298.
- Zhang JZ (2004) Frequent false detection of positive selection by the likelihood method with branch-site models. *Molecular Biology And Evolution* **21**, 1332-1339.
- Zhang JZ, Kumar S, Nei M (1997) Small-sample tests of episodic adaptive evolution: A case study of primate lysozymes. *Molecular Biology And Evolution* **14**, 1335-1338.
- Zhang JZ, Nielsen R, Yang ZH (2005) Evaluation of an improved branch-site likelihood method for detecting positive selection at the molecular level. *Molecular Biology And Evolution* **22**, 2472-2479.
- Zhang JZ, Rosenberg HF, Nei M (1998) Positive Darwinian selection after gene duplication in primate ribonuclease genes. *Proceedings Of The National Academy Of Sciences Of The United States Of America* **95**, 3708-3713.
- Zhang JZ, Zhang YP, Rosenberg HF (2002) Adaptive evolution of a duplicated pancreatic ribonuclease gene in a leaf-eating monkey. *Nature Genetics* **30**, 411-415.
- Zhang L, Cui XF, Schmitt K, *et al.* (1992) Whole Genome Amplification from a single cell - Implications for genetic-analysis. *Proceedings Of The National Academy Of Sciences Of The United States Of America* **89**, 5847-5851.
- Zinn AR, Alagappan RK, Brown LG, Wool I, Page DC (1994) Structure and function o ribosomal protein-S4 genes on the human and mouse sex-chromosomes. *Molecular And Cellular Biology* **14**, 2485-2492.
- Zinn AR, Page DC, Fisher EMC (1993) Turner Syndrome - The case of the missing sex-chromosome. *Trends In Genetics* **9**, 90-93.
- Zinn AR, Ross JL (1998) Turner syndrome and haploinsufficiency. *Current Opinion In Genetics & Development* **8**, 322-327.

