Landsteiner Battles The Apes In Bombay

-Kalyan Banda
“I have recently observed and stated that the serum of normal people is capable of clumping the red cells of other healthy individuals... As commonly expressed, it can be said that in these cases at least two different kinds of agglutinins exist, one kind in A, the other in B, both together in C. The cells are naturally insensitive to the agglutinins in their own serum.”

The case

- 24 year old woman (G₁P₀) of Pakistani descent with no PMH presented for routine prenatal care at 13 weeks during her first pregnancy.

- Type and cross revealed:
  - Forward Type: Patient’s RBCs do not agglutinate with Anti-A or Anti B abs
  - Reverse Type: Patient’s serum agglutinates A, B, and O RBCs
  - What is the patient’s blood group?
ABO antigens

Type-3 H antigen
Type-3 A antigen
Type-3 B antigen
Bombay

- Ser/Thr

Galactose (Gal)  N-Acetylgalactosamine (GalNac)  Fucose (Fuc)
Genetics of ABO

- Sugars NOT proteins
- The gene codes for an enzyme that transfers sugars
- Long arm of chromosome 9

- A - Alpha 1-3-N-acetylgalactosaminyltransferase
- B - Alpha 1-3-galactosyltransferase
- O - ‘Null’ Allele

- Four amino acid differences between A and B

- H - Fucosyltransferase 1 on chromosome 19. Creates H antigen
- **Loss of this enzyme** – Bombay blood group
Genetics of ABO

Chromosome 9q34

Four amino acid changes

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Two amino acids determine enzyme specificity
A and B enzymes are isoforms

ABO gene is highly polymorphic (~250 alleles)
ABO blood groups are not unique to humans

SPECIAL ARTICLES

SEROLOGICAL OBSERVATIONS ON THE
RELATIONSHIP OF THE BLOODS OF
MAN AND THE ANTHROPOID APES

It can be concluded from the foregoing that very probably the group specific factors characteristic for human blood appeared in the phylogeny of the primates prior to the genesis of man.

K. LANDSTEINER,
C. PHILIP MILLER, JR.

ROCKEFELLER INSTITUTE

Science, New Series, Vol. 61, No. 1584 (May 8, 1925), pp. 492-493

“Nothing in Biology Makes Sense Except in the Light of Evolution”
- Theodosius Dobzhansky
If a polymorphism exists across species there are two explanations....

[Diagram A: Trans-species polymorphism]

[Diagram B: Convergent evolution]

B was reinvented by convergent evolution in 6 species

Macaques
Baboons
Gibbons
Orangutans
Gorillas
Humans

The ABO blood group is a trans-species polymorphism in primates

Laure Ségurel, Emma E. Thompson, Timothée Flutre, Jessica Lovstada, Aarti Venkat, Susan W. Margulis, Jill Moyse, Steve Ross, Kathryn Gamble, Guy Sella, Carole Ober, and Molly Przeworski

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Edited by Marcus W. Feldman, Stanford University, Stanford, CA, and accepted by the Editorial Board September 12, 2012 (received for review June 22, 2012)
ABO polymorphism is in over 40 primate species
The same two specific amino acid changes are seen in all primates with B transferase
Identical nucleotide changes in Apes and New world monkeys
Similar changes in old world monkeys
How to infer the ancestry of a gene?
ABO polymorphism is at least 20 million years old (The dawn of apes)
**ABO is a true trans-species polymorphism**

- Apes and Old world monkeys appear to have inherited from a common ancestor making it likely > 25 million years old
- Old world monkey and new world monkeys may have inherited it from a common ancestor possibly making it > 40 million years old
What balancing selective pressures maintain ABO polymorphism across species?

Sexual selection?

Infectious diseases?
- Norovirus – Primary receptor is blood group antigens
- Plasmodium falciparum – O group decreased rosetting, decreased severity and mortality
- Vibrio Cholera – O blood group associated with increased severity

The forces of selection are unknown
Summary

• ABO are sugars
• The polymorphism exists across several species
• Is likely the result of an ancient polymorphism maintained by balancing selection across lineages
• The selective pressures are not clearly defined (maybe infections)
The case

• Normal vaginal delivery at 39 weeks
• Normal child with AB blood group
• Mother and child lived happily every after
Few men who work at the problems of human disease come to the mental
stature of which they are capable. So much there is to see and to do by the
way, such opportunity to gain large practical ends by small mental means, so
much pulling and hauling by the lay public and such wide applause for second-,
third- and fourth-rate achievement, if only it be of use, that to fall away from
the line of the intellect is all too easy. A few men there are, though, who cleave
to it through thick and thin. Karl Landsteiner was one of these.

Peyton Rous
Obituary Notices of Fellows of the Royal Society, Vol. 5, No. 15
(Feb., 1947), pp. 294-324
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