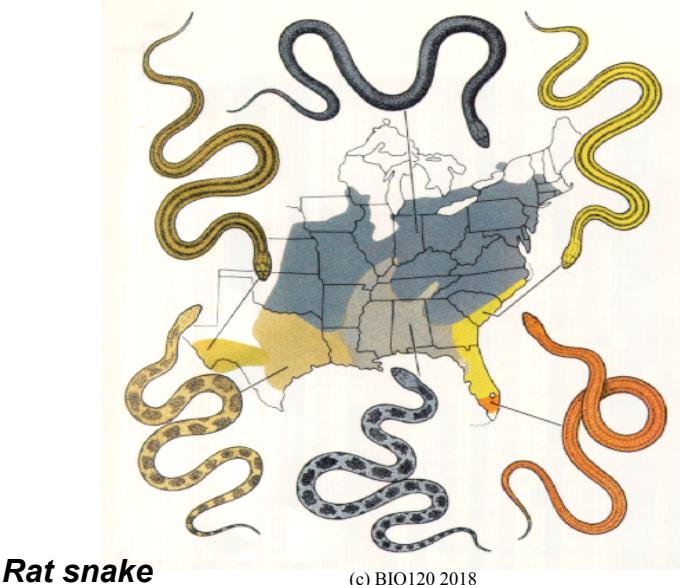
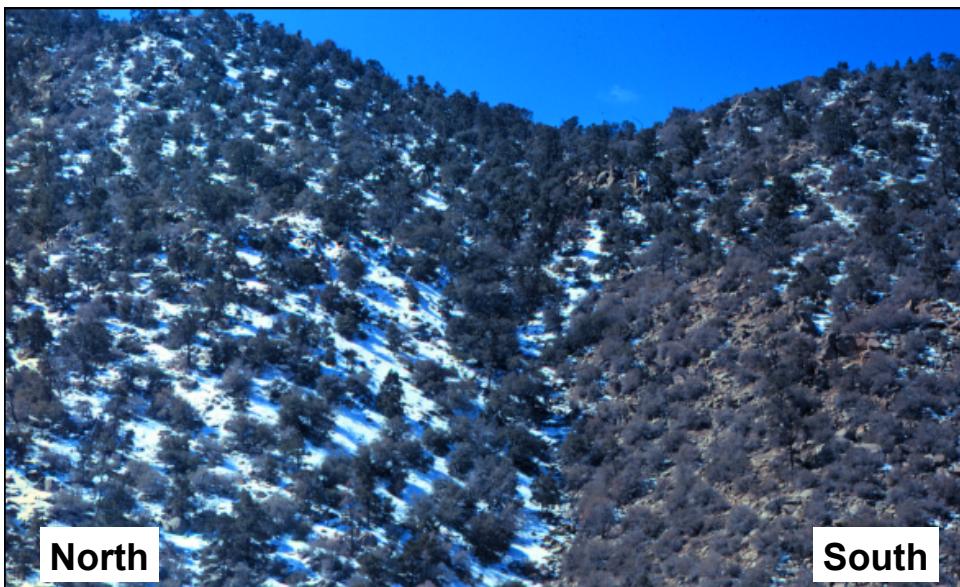


## **Geographic Variation**



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***North- versus south-facing slopes  
have different microclimates***

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## ***Population structure, gene flow & genetic drift***

**Why is there variation between different populations of a species?**

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### ***Some definitions***

#### **Population**

- A group of individuals of a single species occupying a given area at the same time

#### **Migration**

- The movement of individuals from one population to another

#### **Gene flow**

- The movement of genes from one population to another

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## ***RECAP***

### ***Key questions for evolutionary studies of variation within populations***

- How much of the observed variation among individuals is genetic in origin?
- Does the variation contribute to fitness differences among individuals?

**But what about variation among populations?**

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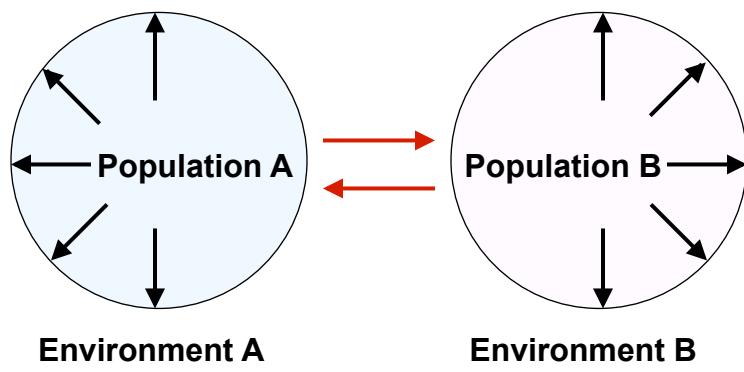
### ***Key questions related to geographic differentiation***

- What proportion of all genetic variation in a species is due to differences between populations?
  - How is diversity distributed within vs. between populations?
- Are some loci or traits more differentiated than the genome-wide average?
  - If so, is this between population differentiation due to local adaptation?

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## ***Effects of selection, gene flow & genetic drift on population divergence***



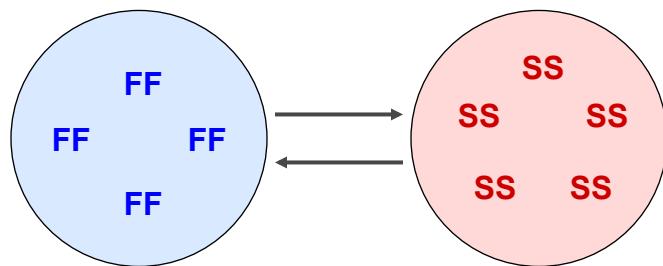
## ***How do we measure gene flow?***

- Difficult to observe and measure
- Distinguish potential vs. actual
- Distinguish gamete vs. individual
- Use experimental approaches
- Use neutral genetic markers\*

\*Polymorphic neutral genetic variation used to study population processes affecting genetic diversity

## ***Two populations fixed for alternative alleles***

**Question:** How much gene flow occurs between them?



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***Measuring gene flow – an example from modern agriculture***

Genetically modified canola

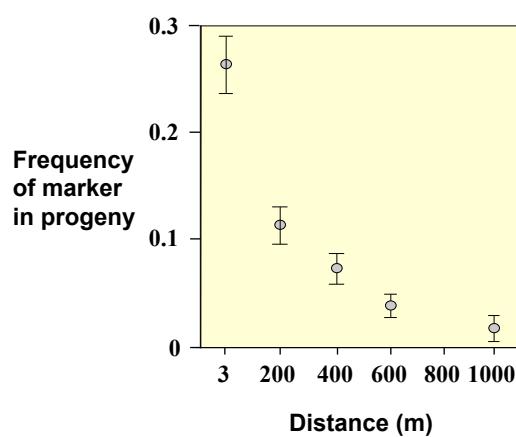
## ***Escape of transgenes\* into wild relatives by gene flow***

- Many crops have close relatives with which they are inter-fertile
  - rice
  - oats
  - canola
  - carrots
- Hybridization between crops and related weeds is well documented

\* Gene transfer by recombinant DNA technology

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### ***Gene flow between crop and weed sunflowers***



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Arias & Rieseberg, 1994

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## ***Escape of crop transgenes into wild relatives by gene flow***

Risk assessment:

- Proximity of wild relatives
- Pollination system - wind vs. animal
- Mating system - selfer vs. outcrosser

**What would be...**

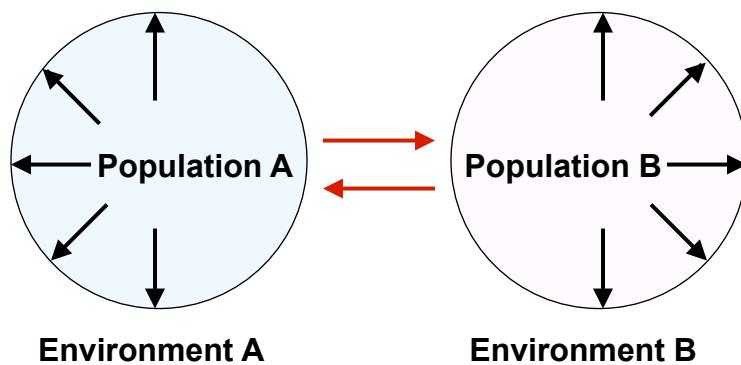
**High risk:**

**Low risk:**

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## ***Effect of gene flow, selection & drift on population divergence***



Effect of Selection & Drift



Effect of Gene Flow



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## ***Genetic Drift***



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### ***What does random mean in evolution?***

- **Stochastic** (unpredictable or random) evolutionary forces:

- Mutation
- Recombination
- Gene flow
- **Genetic drift**



- **Deterministic** (predictable or non-random) evolutionary force:

- Natural selection

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## ***Genetic drift in action***

25 individuals in the population

= 50 alleles in total

		Red	Yellow	Blue
Before flood	# of alleles	25	20	5
	allele frequency	25/50 = 0.5	20/50 = 0.4	5/50 = 0.1
After flood	# of alleles			
	allele frequency			

Stochastic event (**flood**) and only 5 individuals survive = 10 alleles

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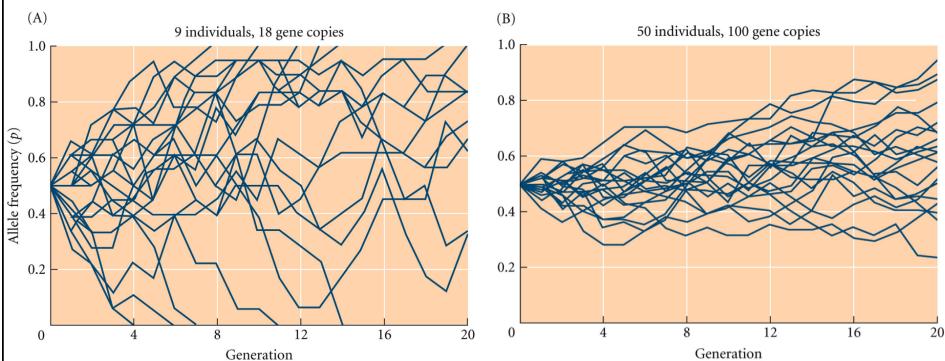
## ***Stochastic processes resulting in a loss of diversity***

- **Genetic drift:** stochastic changes in allele frequency due to random variation in fecundity & mortality; **most important when populations are small**
- **Population bottlenecks:** a single sharp reduction in numbers causing a loss of diversity
- **Founder events:** colonization by a few individuals that start a new population with only limited diversity compared with the source population

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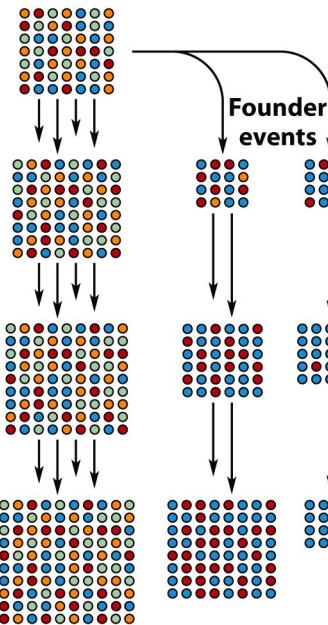
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## ***Random fluctuations in allele frequencies in populations of different size***



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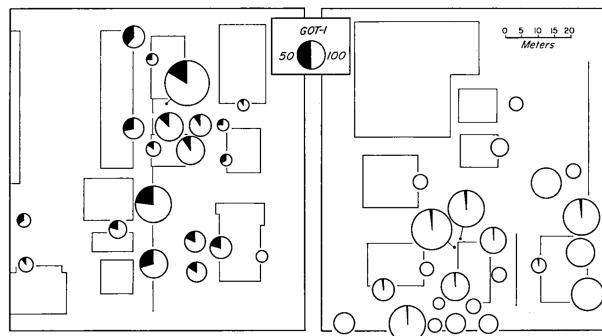
***Other stochastic  
processes which  
reduce diversity***

**Ricklefs p. 278**

Figure 13.9  
*The Economy of Nature*, Sixth Edition (c) BIO120 2018  
© 2010 W.H. Freeman and Company

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## ***Population differentiation by drift in snails***



sampled allele frequencies at 5 loci (GOT-1 shown) for snail *Helix aspersa* groups on two city blocks

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Selander & Kaufman 1974

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## **Differences between populations within a Species**

- Genetic differentiation among populations is often observed across a geographic range
- The population differentiation may be due to:
  1. local adaptation
  2. phenotypic plasticity
  3. genetic drift

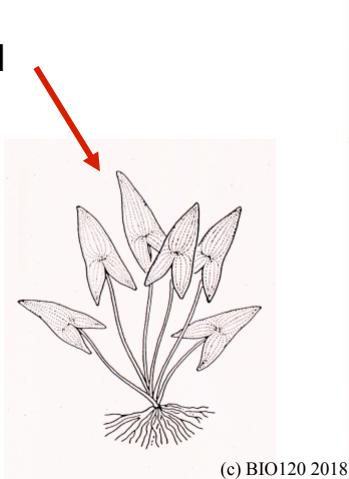
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## **Phenotypic Plasticity** Can Contribute to Populations Looking Different

- Terrestrial and aquatic phenotypes of Arrowhead, an aquatic plant common in Ontario wetlands

**Aerial**



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**Submersed**



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## **Phenotypic Plasticity**

The ability of a genotype to modify its phenotype in response to changes in the environment

- Occurs through modifications to growth and development
- Under genetic control
- Phenotypic plasticity often an adaptation to unpredictable environments

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## Transplant Studies

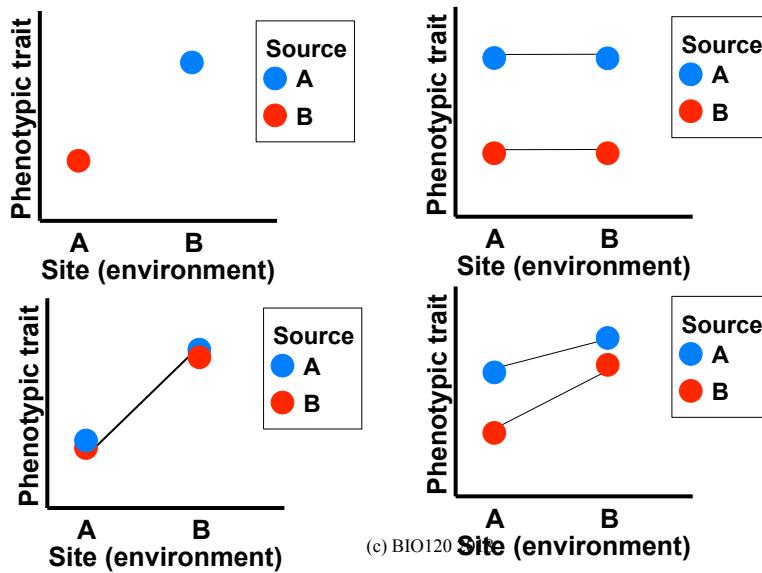
grow clones from different sites in different environments and measure their phenotype and performance

- Enables measurement of selection on non-native vs local genotypes
- Can decompose phenotypic variation into genetic and environmental components

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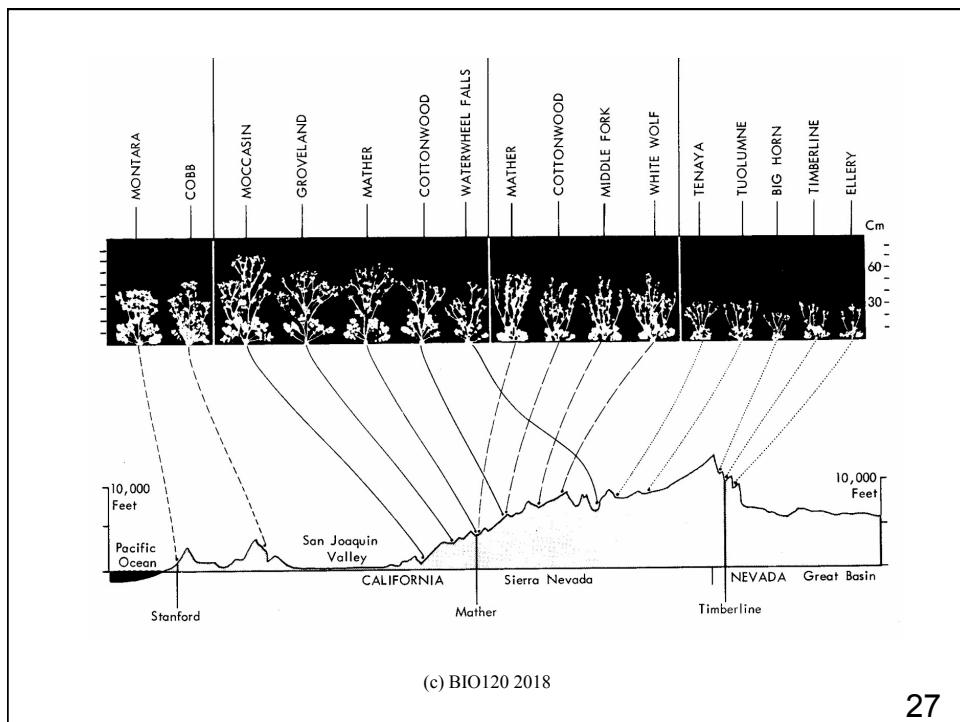
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## Reciprocal transplant experiments



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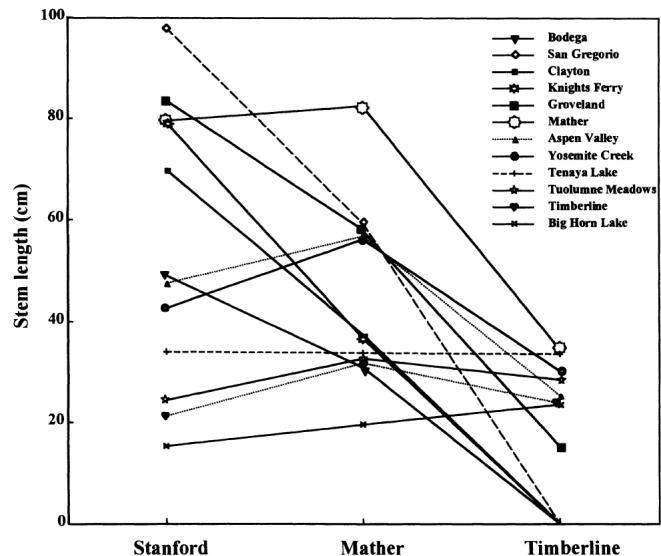
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### Transplant Experiment with *Potentilla glandulosa*

Grown at From ↓	→ Stanford 30.4-182.4 m (100-600 ft)	Mather 1398.4 m (4600 ft)	Timberline 3040 m (10,000 ft)
Stanford 30.4-182.4 m (100-600 ft)			Fail to survive
Mather 1398.4 m (4600 ft)			
Timberline 3040 m (10,000 ft)			

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## ***Results from reciprocal transplant***

- they found variability for numerous morphological and physiological traits among populations
- native plants had higher survival and reproduction relative to transplant plants
- there was genetic differentiation in morphology and especially physiology

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## ***Genomics for studying local adaptation***

- sequence DNA from samples of different populations
- compare genetic diversity (SNPs) between populations
- areas of DNA that show higher between-population divergence than average gene may be involved in local adaptation

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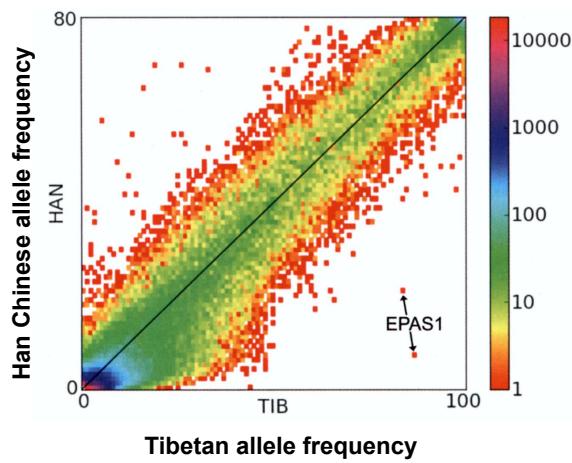
## ***Adaptation to high altitude***



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## ***Adaptation to high altitudes***



Yi et al. 2010

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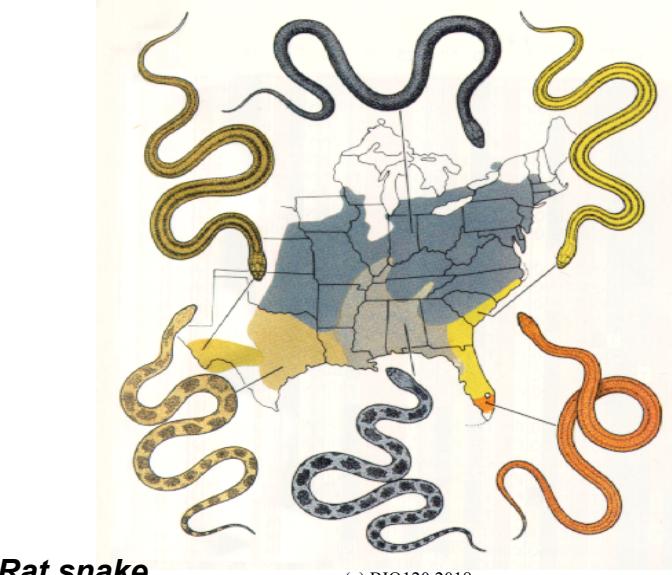
## ***Adaptation to high altitude***

- Alleles at the EPAS1 gene show high divergence between Tibetan and Han populations
- Result of positive selection in Tibetan population
- This gene is involved in the regulation of red blood cells

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### ***Geographic Variation***



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