



Invasive rat colonization history and movement dynamics in Haida Gwaii



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Why do we care about invasive species?

 **BIODIVERSITY**

- Predation/competition
- Niche displacement
- Disease
- Hybridization/Introgression
- Extirpation & extinction

Invasive species have huge economic impacts

- \$220 billion/year – USA (2011)
- \$1.4 trillion/year - Global (2013)
- Removal, agriculture losses, disease treatment/prevention, etc.

We need efficient management strategies

- Where should we focus?
- Prevention is best
- Containment/eradication costly

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Genetics can inform
management
decisions

What can we learn about invasives using genetics?

- Historical origin(s)
- Number of introductions
- Invasion pathway

Rats are among the most invasive mammals...

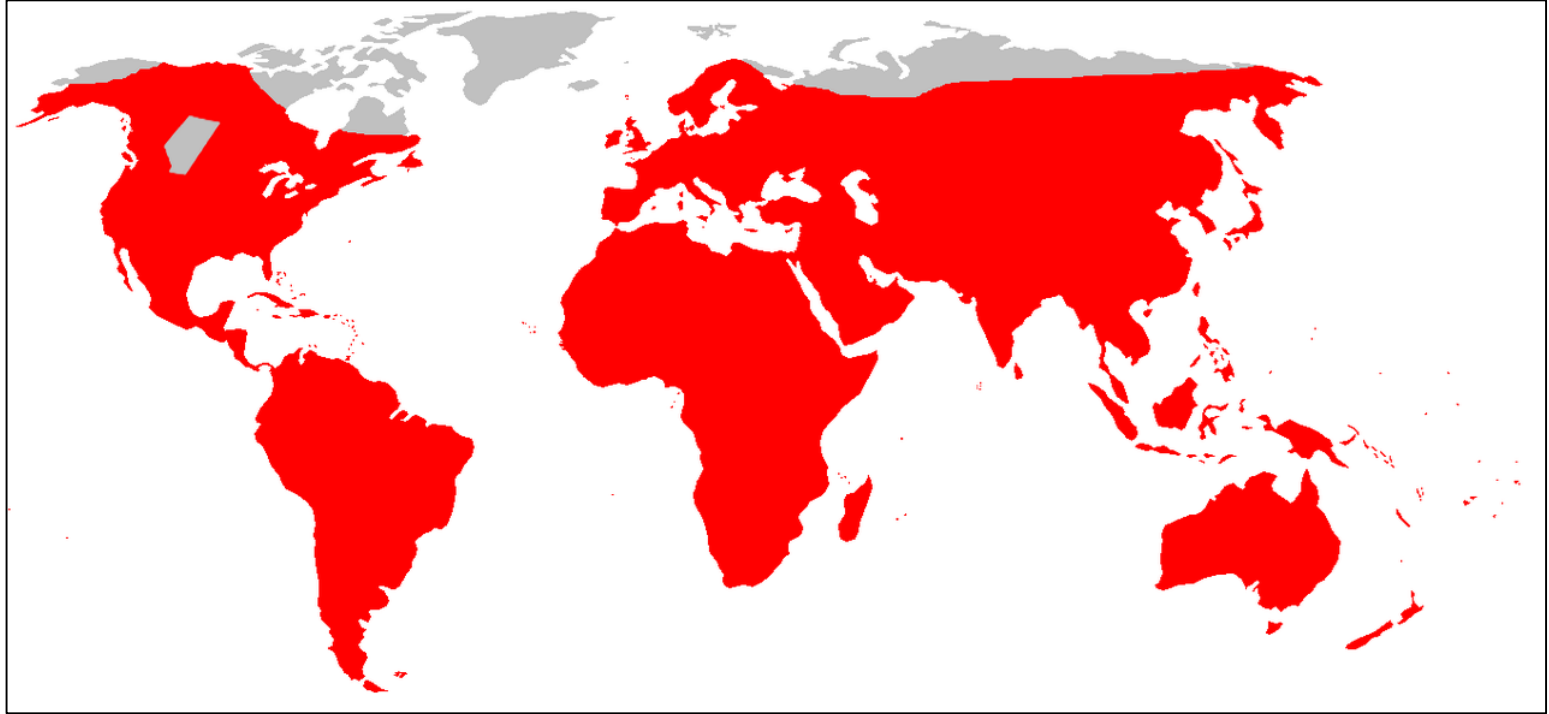


By Kilessan - Own work, CC BY-SA 3.0,
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By Reg Mckenna - originally posted to Flickr as Wild Rat, CC BY 2.0,
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...and have a widespread distribution



https://en.wikipedia.org/wiki/Brown_rat#/media/File:Brown_rat_distribution.png

Rats are generalist omnivores with high reproductive rates

- 8-10 pups/litter
- 5-7 litters/year
- Can reach sexual maturity as early as 4 weeks old



http://www.kimballstock.com/pix/ROD/03/ROD_03_KH0006_01_P.JPG

Rats are excellent competitors

- Outcompete/predate upon native fauna
- Can lead to range contractions, declines, extirpations, and extinction
- 40% and 60% of all seabirds and reptile extinctions, with 90% of those occurring on islands

Island fauna are particularly sensitive to rat invasions

- Terrestrial predators are limited/absent
- Seabirds experience most severe impact
- Rats predate on nests (eggs, chicks, adults)



<https://static.stuff.co.nz/1361486630/234/8339234.jpg>

1.5 million seabirds across 12 species nest in Haida Gwaii

- Ancient murrelet (*Synthliboramphus antiquus*)
- Cassin's auklet (*Ptychoramphus aleuticus*)



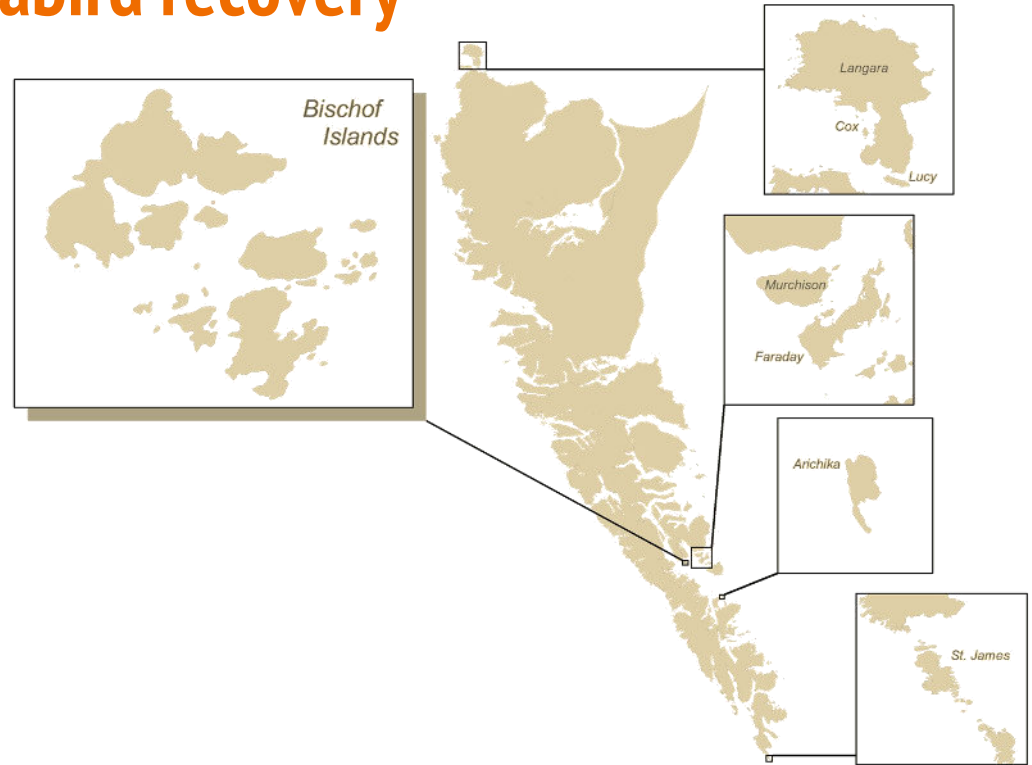
Rats invaded Haida Gwaii in the 1700s

- Found on at least 20 islands
- Rats have caused at least 6 seabird species declines



Eradications to promote seabird recovery

- Langara, Lucy, Cox (1997)
- St. James (1998)
- Arichika (2011)
- Faraday and Murchison (2012)
- Bischofs* (2003, 2011)



Research Objectives

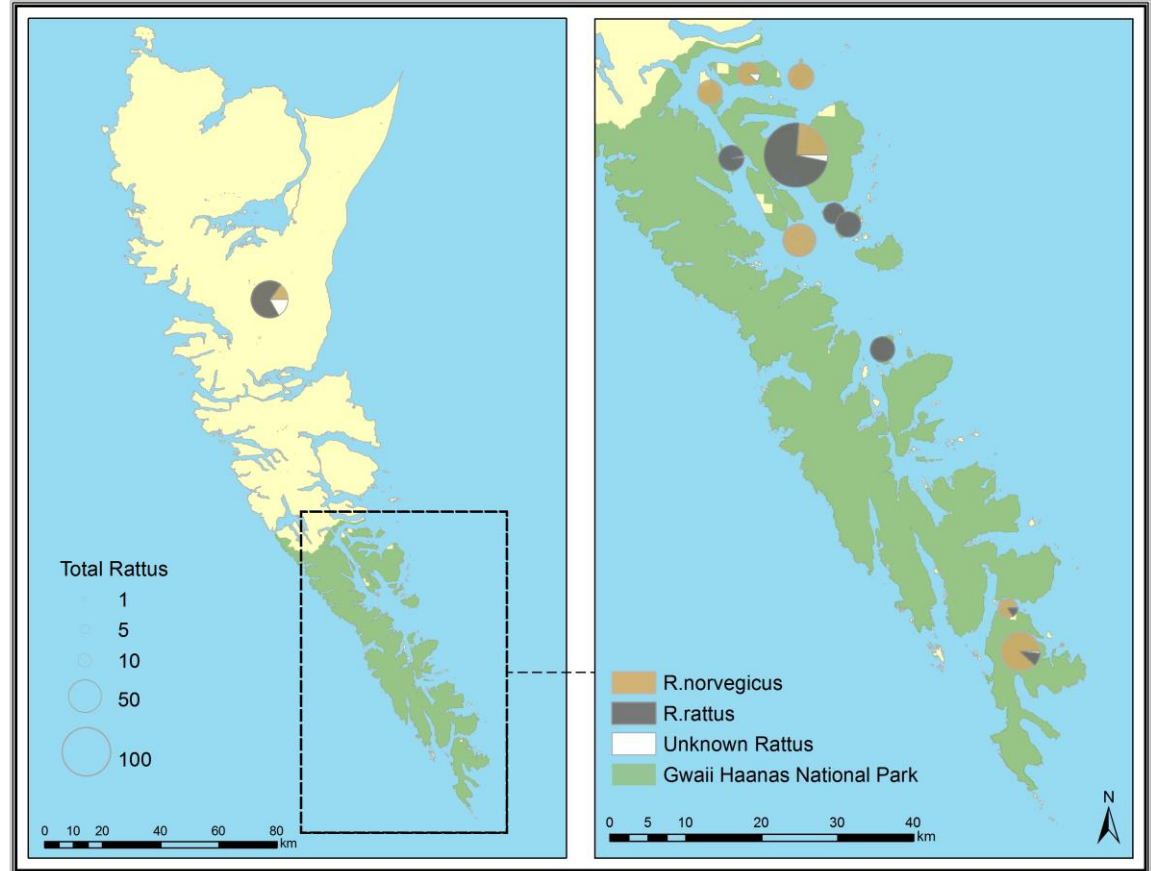
- 1) Identify/quantify extent & direction of gene flow among populations
- 2) Test re-invader vs. survival hypothesis for Bischofs
- 3) Reconstruct global origin(s) of brown rats in Haida Gwaii



FORDHAM UNIVERSITY
THE JESUIT UNIVERSITY OF NEW YORK

551 rats sampled from 2008-2016

- n=290, *R. rattus*
- n=246, *R. norvegicus*
- n=15, unknown

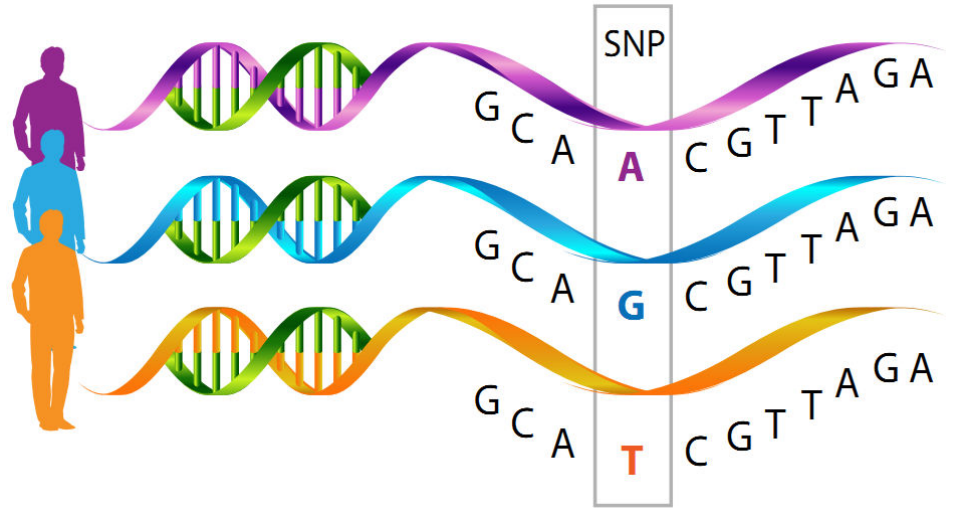


Ears were removed for genomic analysis



Whole genomic DNA was extracted and genotyped

- Use to construct **double digest restriction site associated DNA sequencing** (ddRAD) libraries
- Single nucleotide polymorphisms (SNPs)
- No *a priori* knowledge
- Many individuals
- Low cost



<https://neuroendoimmune.files.wordpress.com/2014/03/snp.png>

288 samples have been sequenced

- Raw data processed and demultiplexed
- Aligned to reference genome

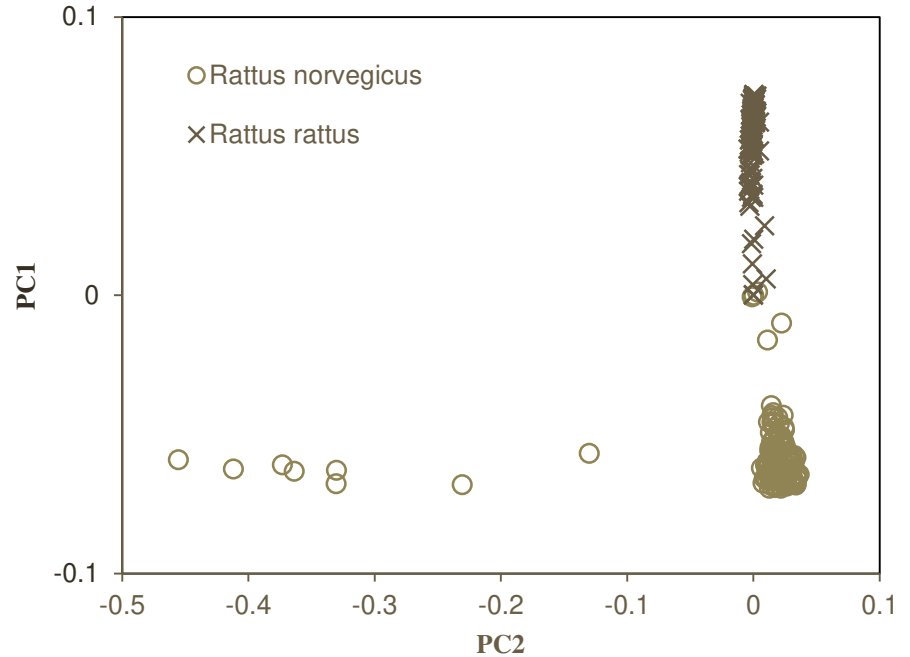
Library	No.Reads	No.Base Pairs	Quality
1	217,226,502	54,306,625,500	34.5
2	236,254,061	59,063,515,250	35
3	257,468,458	64,367,114,500	34

Identify and Genotype SNPs

Species	No.Loci	Coverage
<i>rattus</i>	21 906	16.7x
<i>norvegicus</i>	12 177	16.9x

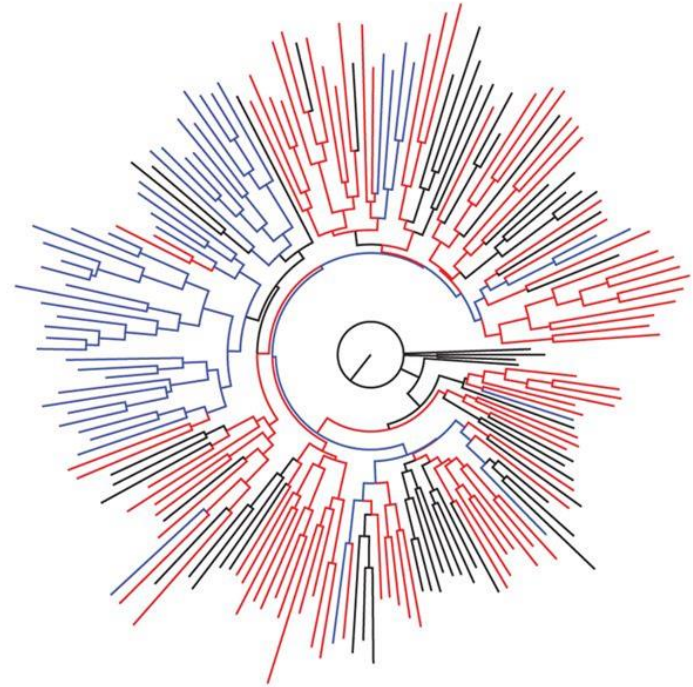
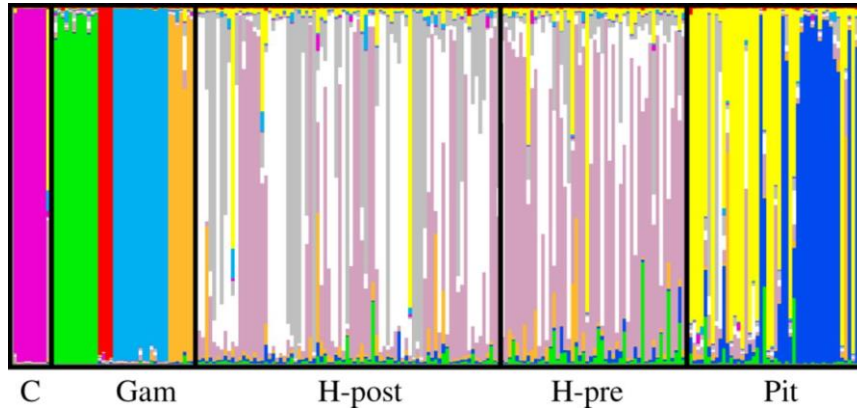
Identify species

- SNPRelate, ADMIXTURE



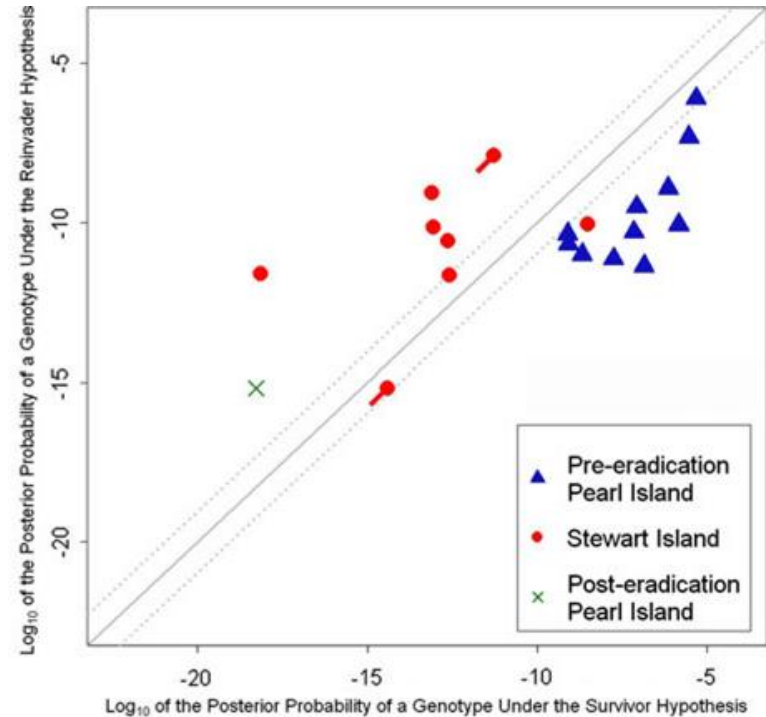
Identify population structure

- Model/distance based clustering



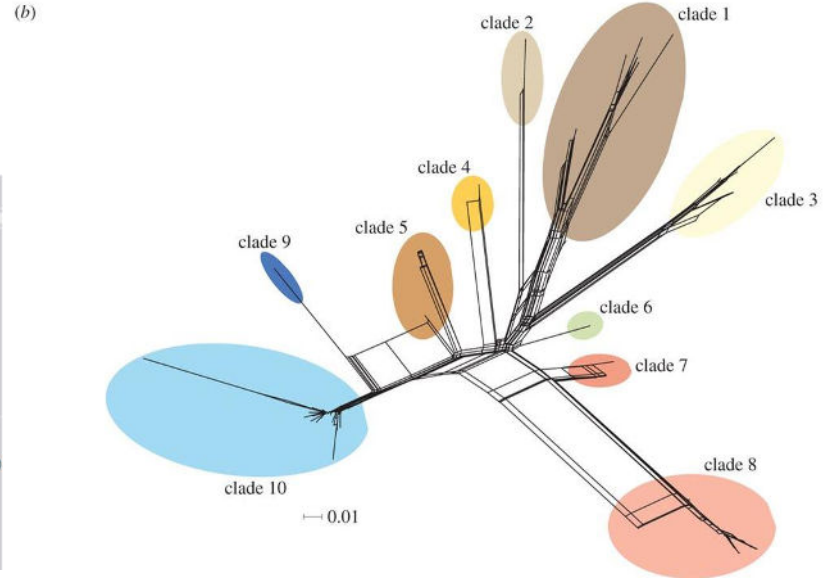
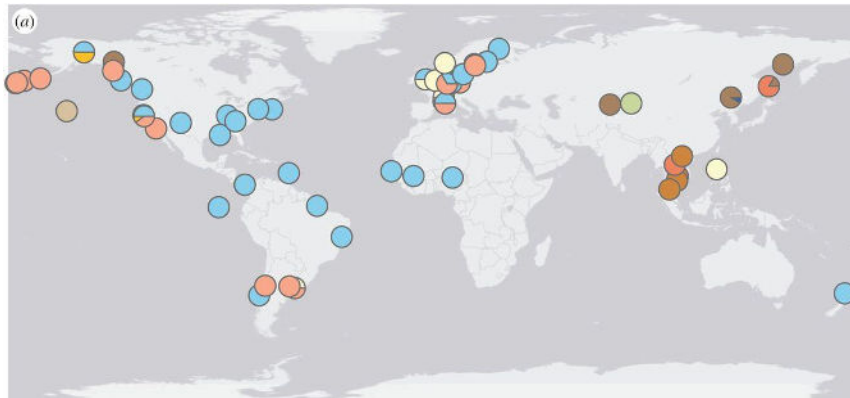
Survivor vs invader on the Bischofs

- Identify a bottleneck (change in allele frequency, heterozygosity excess)



Identify global origin of brown rats - Fordham University

- mtDNA haplotypes, clustering methods



Implications for invasive rat management

- Identifying candidate islands for eradication
- Defining eradication units
- Determining efficacy of eradication
- Develop a better understanding of invasion processes

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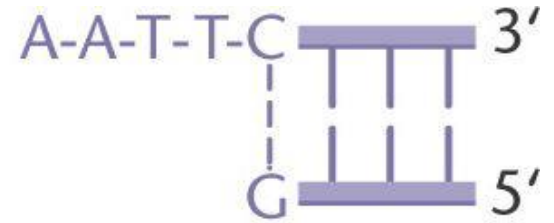


Start by digesting gDNA with two restriction enzymes

- Produces many fragments of variable size
- Fragments have “sticky ends”



Fragments with
sticky ends



Ligate barcode and index



Fragments are size selected



<http://www.sagescience.com/wp-content/uploads/2014/01/pippin-prep-hero.png>

Individuals are pooled into libraries, amplified

