Minnesota Hop Growers Annual Meeting
9th March 2024

Modernising UK hop breeding

Dr Klara Hajdu

Wye Hops

Research and breeding programme supporting the British Hop Industry

Established in 2007 following the closure of Wye College

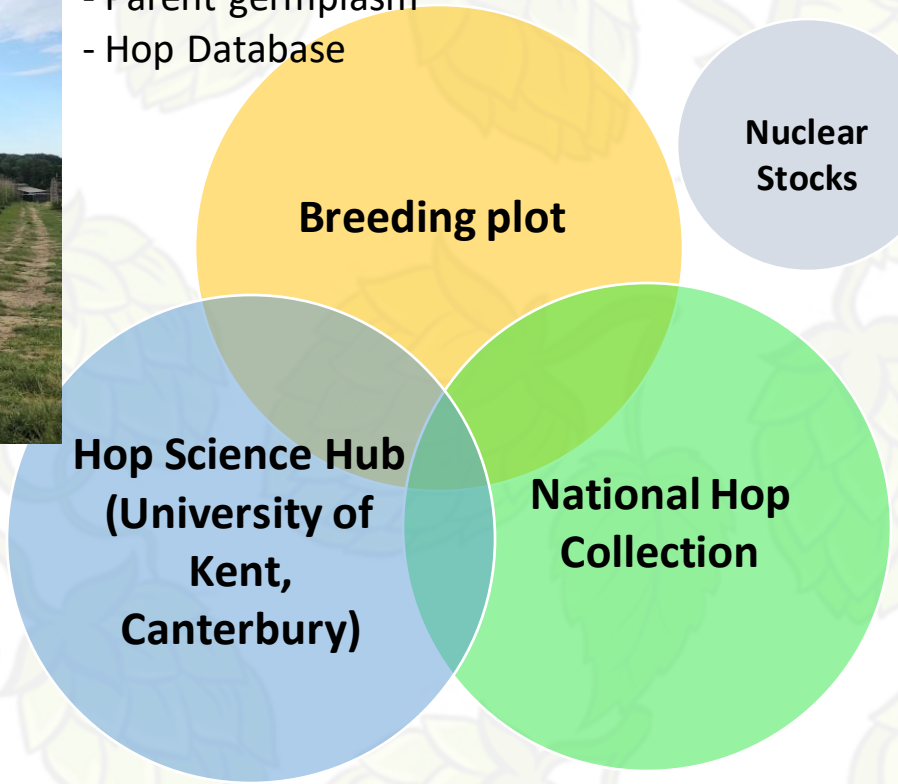
Based at a commercial hop farm in Canterbury, Kent (China Farm)

Subsidiary of the British Hop Association (BHA)

Where is Wye Hops

- Seedling plot
- Selection plot
- Parent germplasm
- Hop Database

- Virus free stocks of BHA varieties and important breeding lines



- Genetic assisted breeding
- Verticillium wilt research
- Cone chemistry analyses
- Hop cytology

- Over 600 genotypes
- Historic varieties
- Important breeding lines
- Wild hops
- Collection of useful inheritable trait

SINCE 1698
SHEPHERD NEAME
BRITAIN'S OLDEST BREWER

UK hop breeding goals?

Economical challenges

Market trends

Environmental challenges

Photo credit: Havill 2022

Photo credit: Havill 2022

A commercial hop variety needs to meet all of these demands!

Breeding to meet the demand…

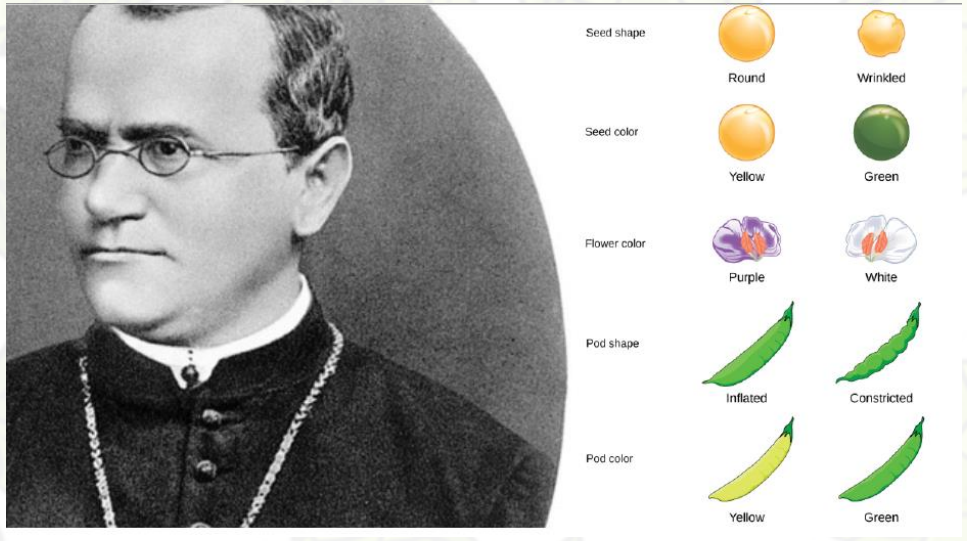
A bit of history…

- Hops have been cultivated in England since the 15th Century
- Landrace hops e.g. Fuggle and Goldings susceptible to diseases
- Scientific hop breeding began in 1906 at Wye College

Breeding to meet the demand…

A bit of history…

- Professor Ernest Salmon, Wye College – 1920s powdery mildew resistance of hop
- Mendel's principles of genetic inheritance



A century of hop breeding to meet the demand…

Powdery mildew resistance (1920s-)
Zenith, Target

Wilt resistance (1970s-)
Target, Pilgrim

Aroma and flavour (2000s-),
Endeavour, Ernest

Drought resistance, spring dormancy…(2020s-)

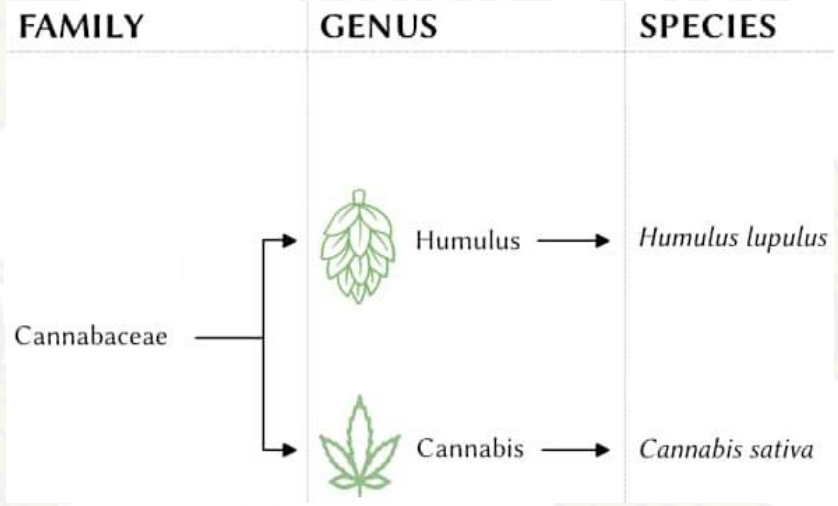
High alpha (20th Century-)
Brewer's Gold, Admiral

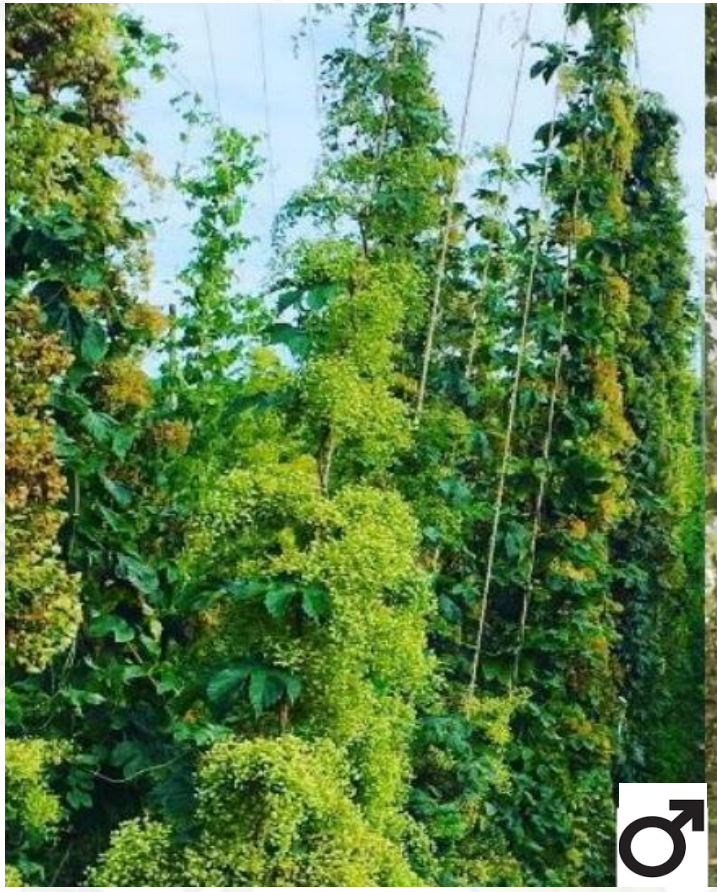
Dwarf Hops, Aphid resistance (1980s-)
First Gold, Boadicea

Some hop facts…

- *Humulus lupulus var. lupulus* - beer hop
- Member of the Cannabaceae family
- Separate **male ♂ and female ♀ plants**
- Female cones are commercially important.

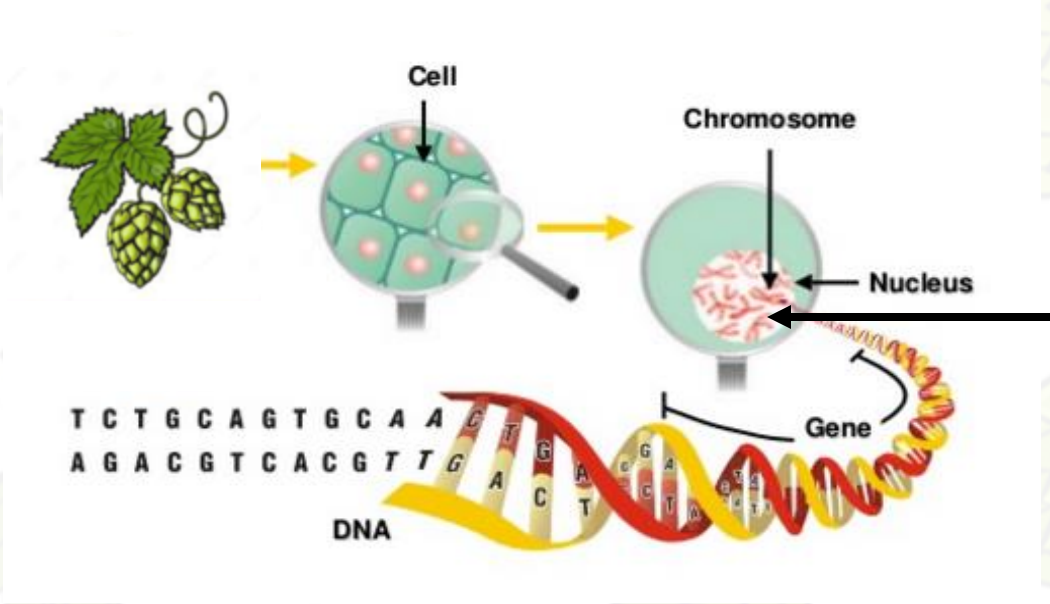
  Males used for breeding!

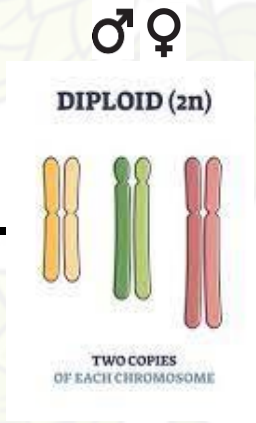


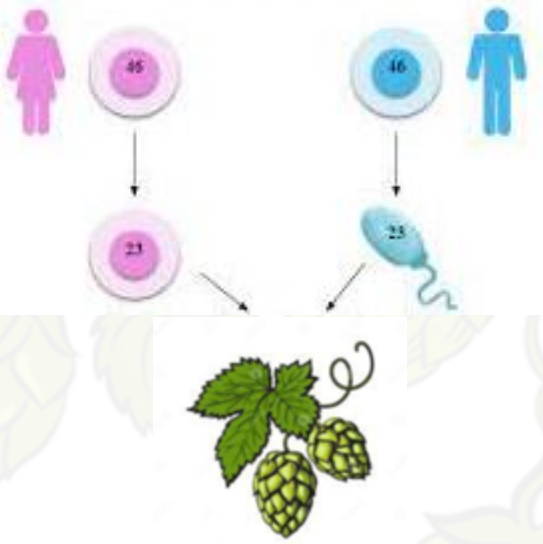


Some more hop facts…

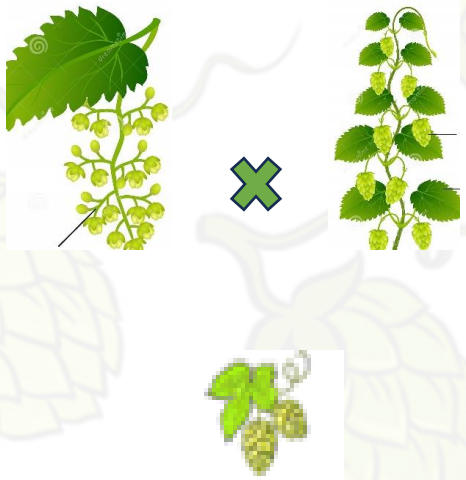
- **Male hops are just as important as female hops for breeding!**
- **Diploid genetics;** with two sets of chromosomes (similarly to humans)
- And a **similar size DNA (3 billion base pairs) to the human genome** encoding roughly 40k different genes







How is breeding achieved in hop?



Breeding is creating cultivars with higher yield, better quality, better tolerance to stresses etc…

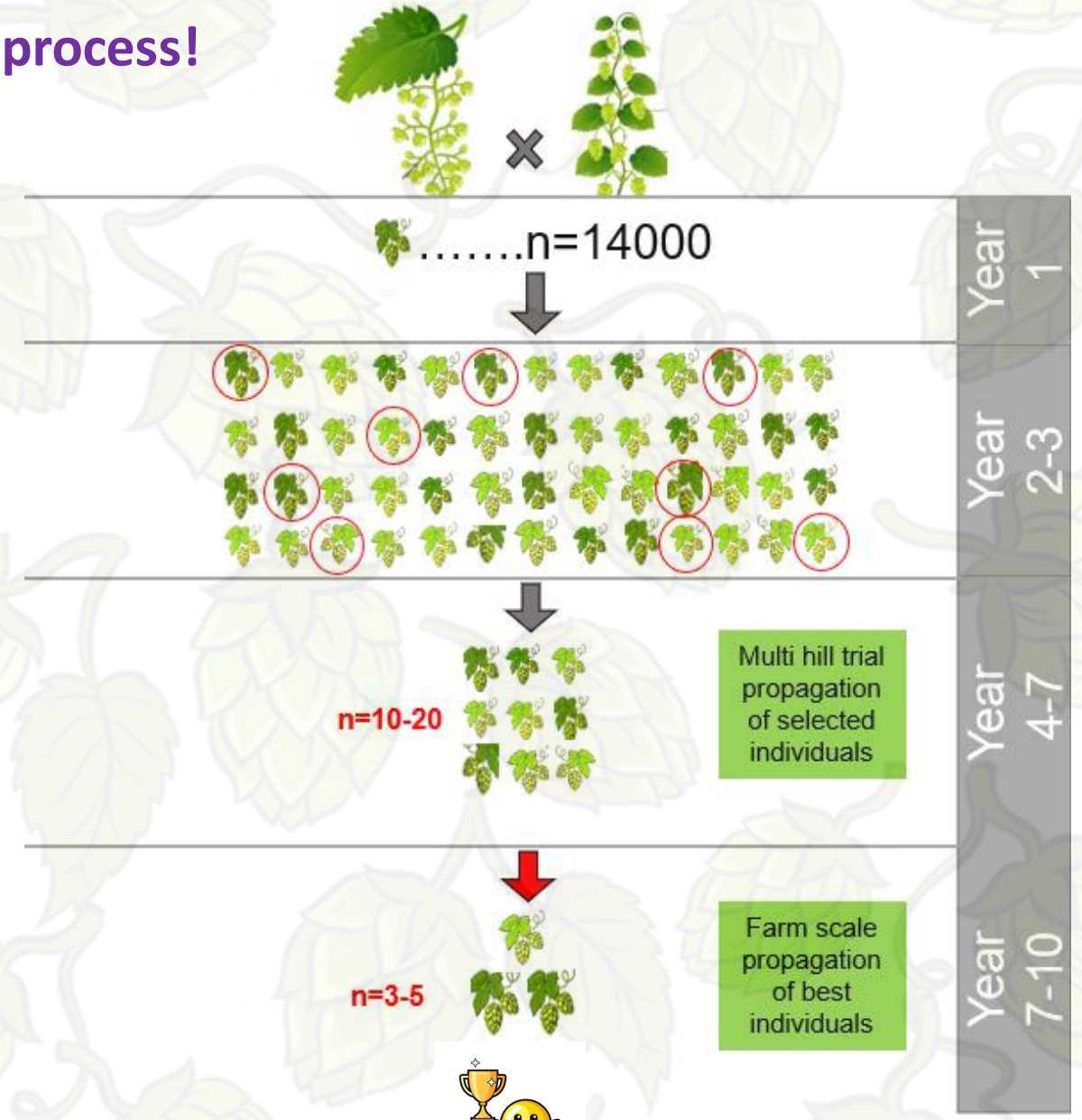
This is achieved through crossing two parents with desirable traits and selecting their best offsprings

.

Selection of hops is based on visual assessment of traits in individuals. Examples are:

- Female hops vs male
- Hops that are disease resistant
- High yielding
- Have distinct aromas

Hop breeding is a numbers game and it’s a long process!



UK hop breeding practices

Year 0 - on field

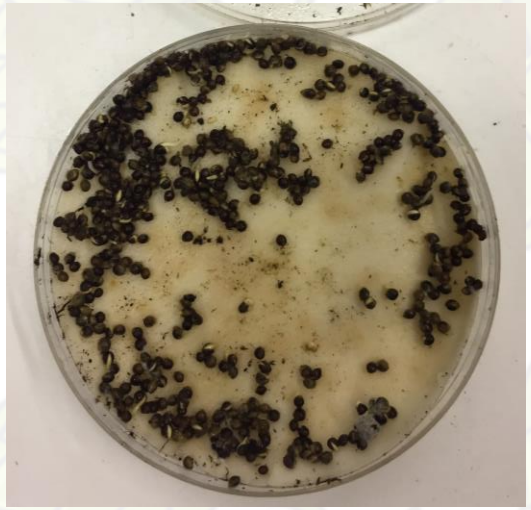
Crossing on field, seed collection

Year 1 – glass house

Seed sowing

Glass house disease screenings of

Downy mildew and Powdery mildew



UK hop breeding practices

Year 1-3 – on field

Seedling stage (single hill individuals)

Agronomy, habit, aroma, pest and disease

Small scale experimental brewing

Year 4-7 – on field

Selections (two hill “Blocks”)

Perennial observations

Wilt screening

INŠTITUT ZA HMELJARSTVO
IN PIVOVARSTVO SLOVENIJE
Slovenian Institute of Hop Research and Brewing

UK hop breeding practices

Year 8-12 – on commercial farms

Multi hill trials

Agronomy and consistency of traits

Large scale brewing trials

Commercial uptake

New practices – Marker assisted breeding

Genetic markers are extremely useful for disease resistance breeding...

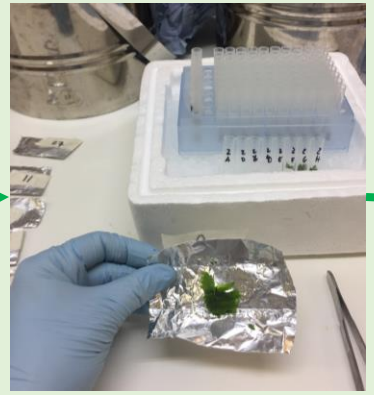
Grower's perspective

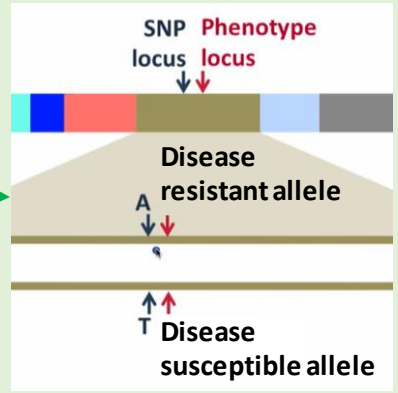
Prevent yield losses

Cost effective disease control

Durable resistance against pathogens

Reduce dependency on pesticides





Breeder's perspective

Confirming resistance in breeding lines

without infection assays

Cost effective/quicker selection

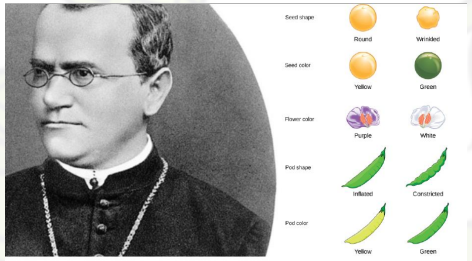
Durable resistance against pathogens

And other traits such as aroma, yield, habit and sex!

Things to consider when breeding…

How an individual plant's traits (phenotype) are expressed is greatly influenced by two things

1. Genetics: the set of genes carried by the individual
2. Environmental conditions: such as climate, soil conditions etc the individual is exposed to

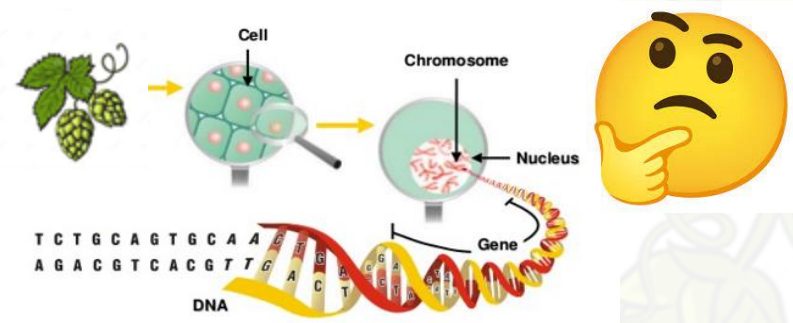


Breeders can only breed for inheritable traits:
Genes passed down from the parents to offsprings

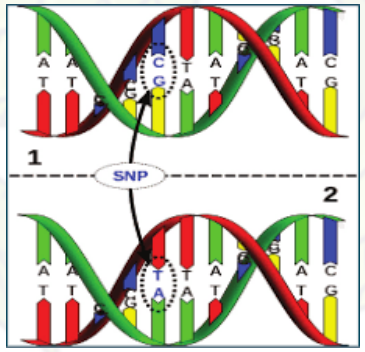
Understanding the genetic components affecting phenotype:
Genetic assisted breeding

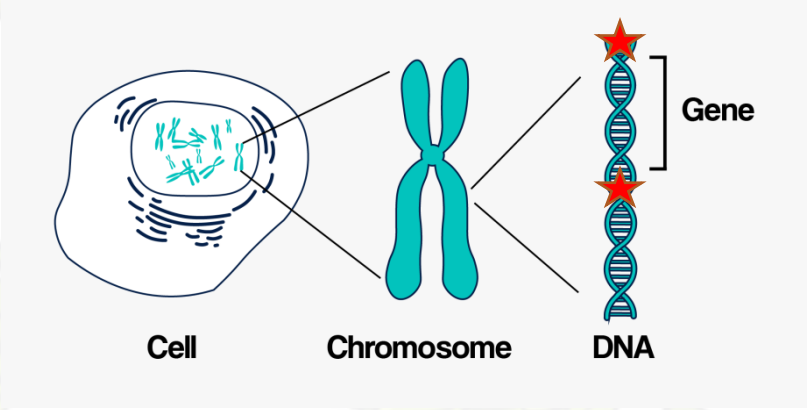
Genetic assisted breeding

Genetic markers

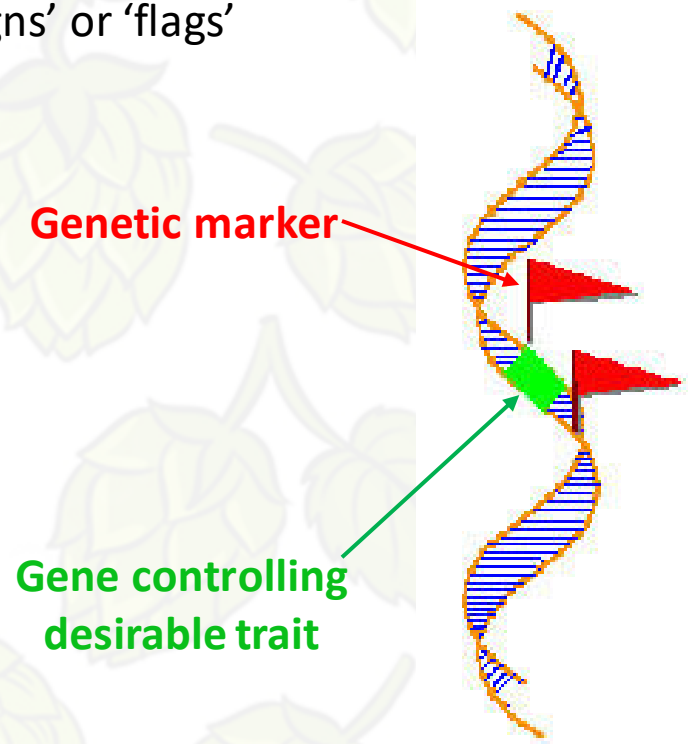


- Finding short DNA fragments, different in different individuals





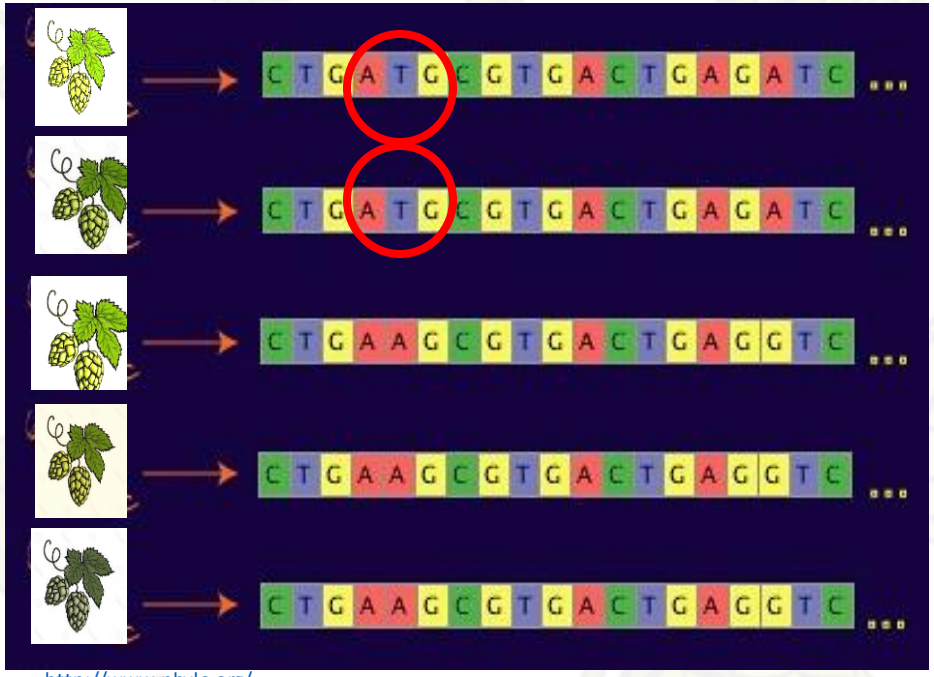
- These fragments are often found close to GENES that control interesting traits
- Act as ‘signs’ or ‘flags’



isaaa.org

Genetic assisted breeding

How it works



http://www.phylo.org/

Association of genotype (DNA marker patterns) and phenotype (expressed trait) in the same individuals

Can we improve our breeding practices?

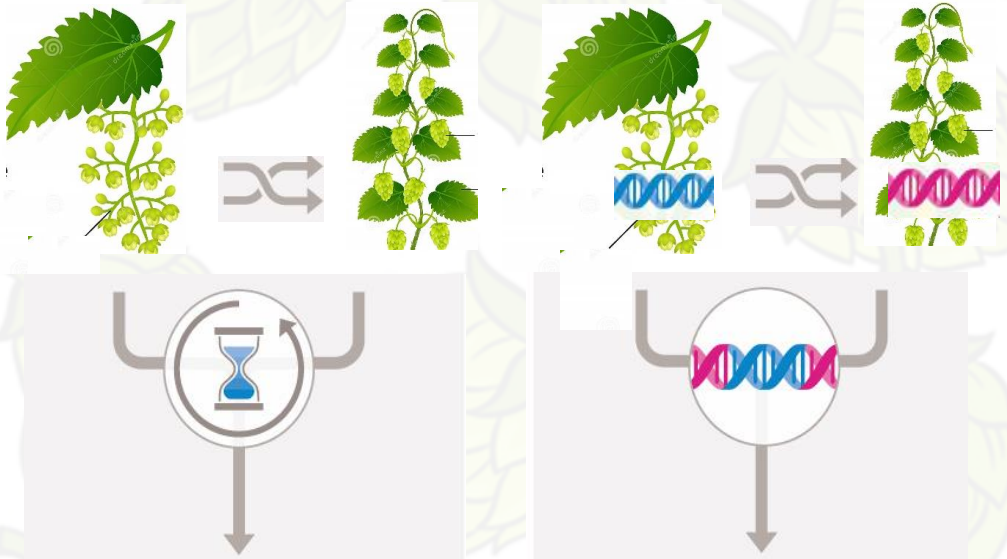
Classical breeding

Long selection time, trait assessed visually, labour and resource intensive

Disease resistant parent

OR

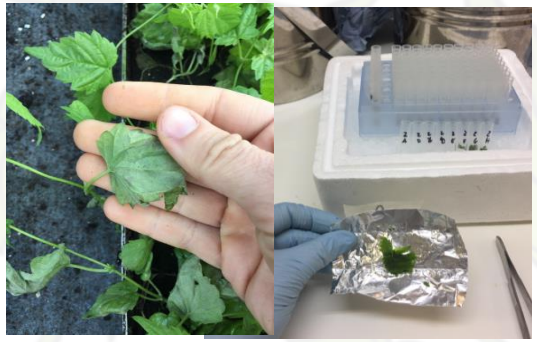
Parent with good aroma



Disease resistant hop with good aroma!

Molecular breeding

Confirm resistance to diseases, sex and other traits from a single leaf sample,



Safeguarding the future of British hops…through breeding

Understanding the genetic basis of hop traits is interesting but it is also useful!

- ✓ Confirm disease resistance without visually assessing whether the plants are resistant
- ✓ Shorten the long selection process
- ✓ Respond to disease and climate challenges quicker
- ✓ Fast track the development of new, British hop varieties for British breweries

Safeguarding the future of British Hops… through research

Partners

University of Kent

NIAB

Charles Faram 1865 United Kingdom

University of Greenwich

NRI | Natural Resources Institute

BSPG Laboratories Limited

Wye Hops Science Hub currently ongoing projects

- Developing simplified assay for phenotyping hop aromas
- The effects of solar panel and tinted lights on hop development and cone chemistry
- Genomics and hop sequencing
- Hop powdery mildew resistance mapping
- Genetic assisted breeding of climate resilient UK hop
- Understanding *Verticillium nonalfalfae* the causal agent of V. wilt in hop
- Understanding chromosomal anomalies in hop
- Exploiting hop metabolites for cancer research

With funding from

Growing Kent & Medway

SoCoBio DTP

BBSRC bioscience for the future

UKRI Innovate UK

Shepherd Neame Since 1698 Britain's Oldest Brewer

BBPA The Voice of Brewers & Pubs

Thank you

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