

Heat Effects on Rice

Johnny Saichuk

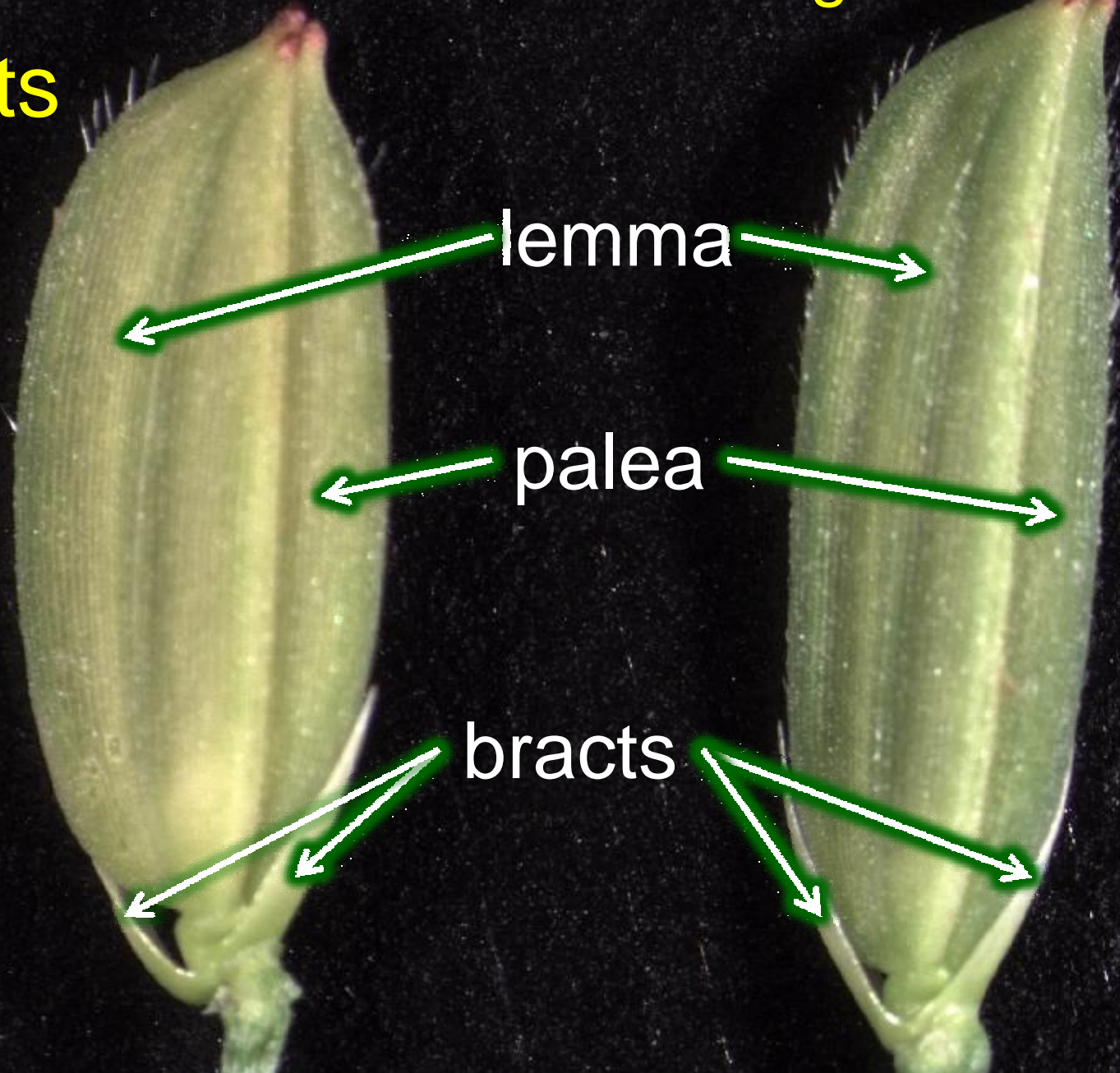
Rice Specialist



Rice Spikelets

Medium Grain

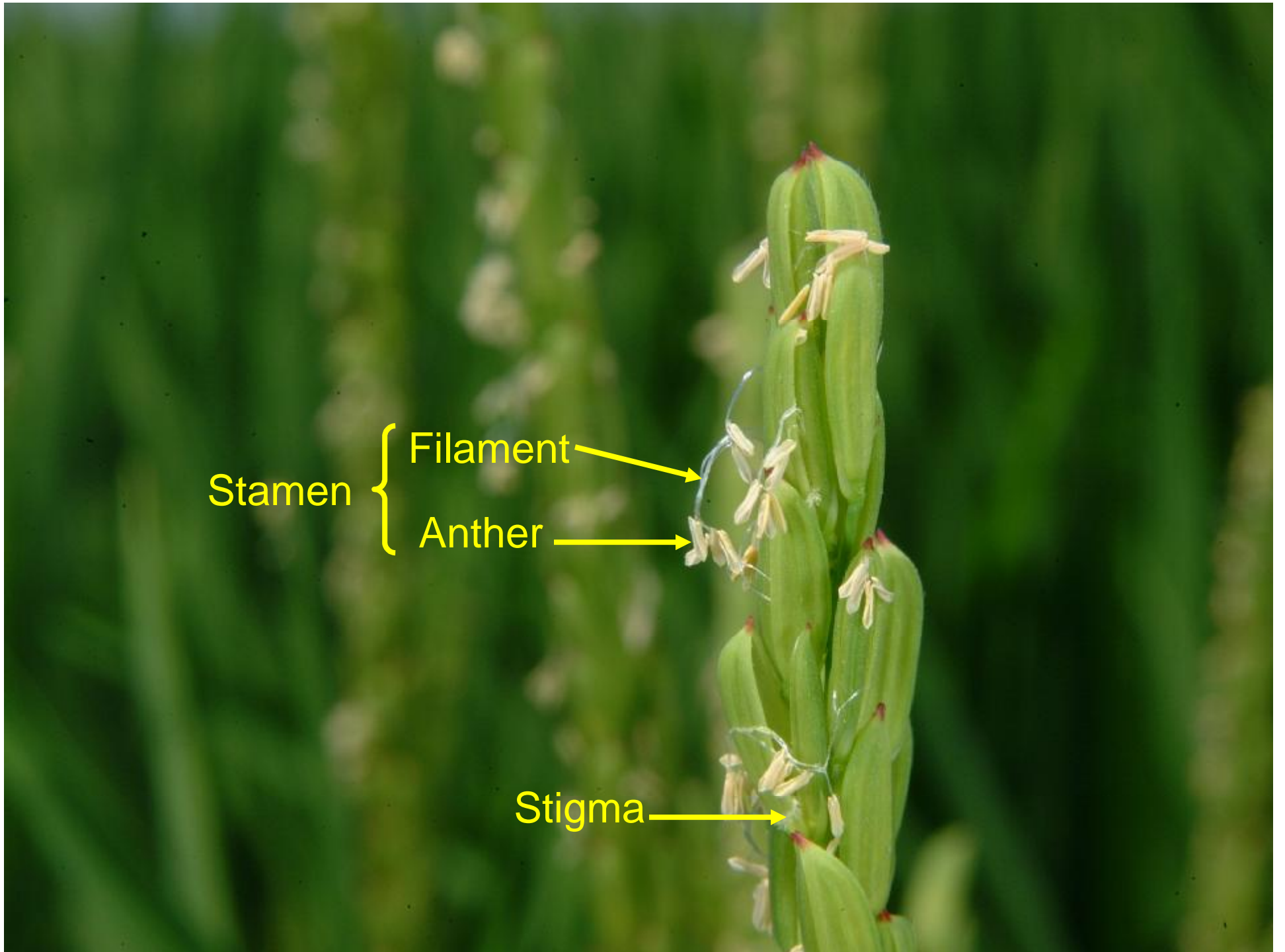
Long Grain



lemma

palea

bracts



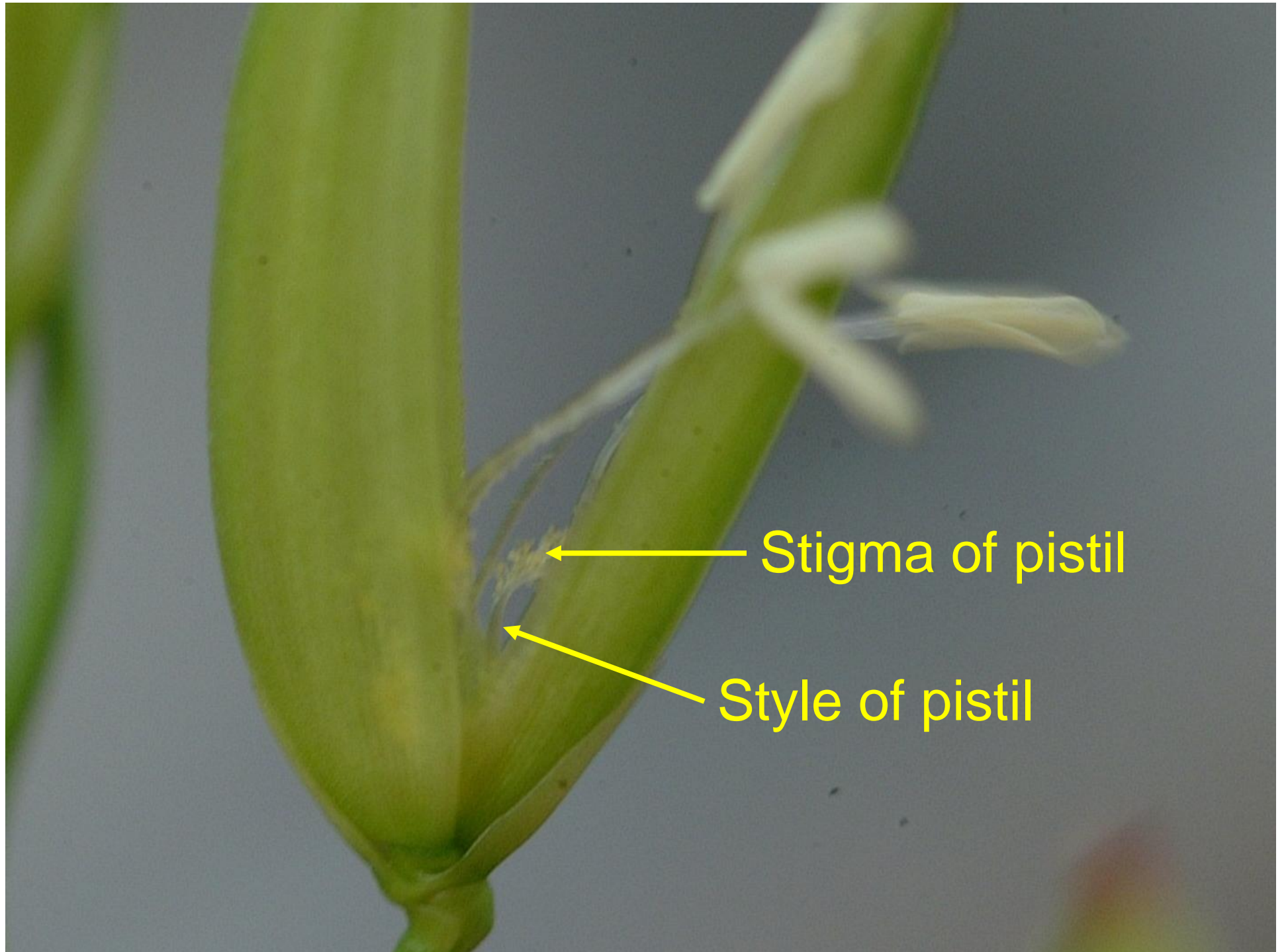
Stamen { Filament
Anther

Stigma

A close-up photograph of a green flower bud against a dark background. The bud is covered in fine droplets of water. Several stamens are visible, with their filaments extending from the bud. The anthers are yellowish and elongated. White arrows point from the text labels to the corresponding parts of the stamens.

Filaments of
stamens

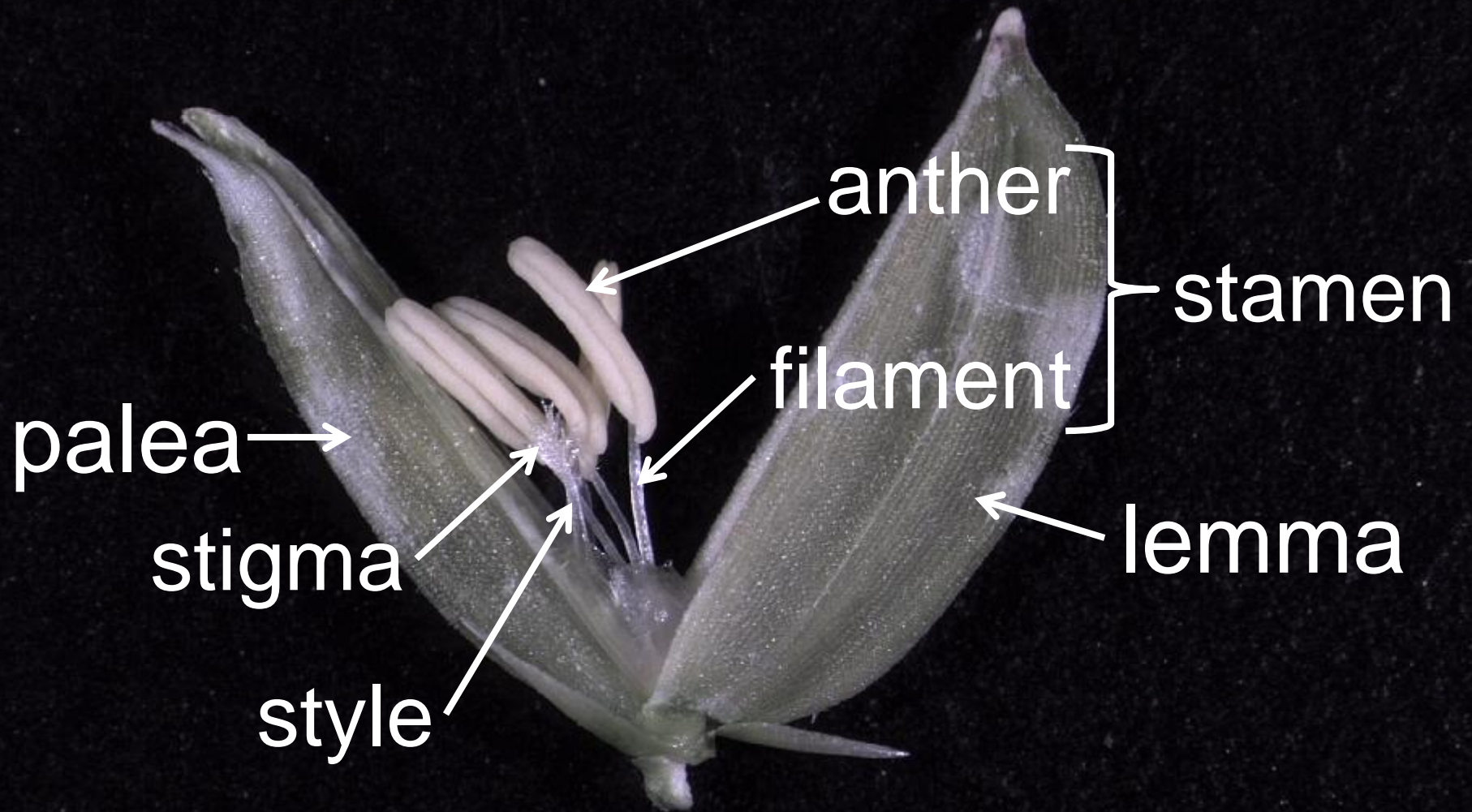
Anthers of
stamens



Stigma of pistil

Style of pistil

Rice Spikelet

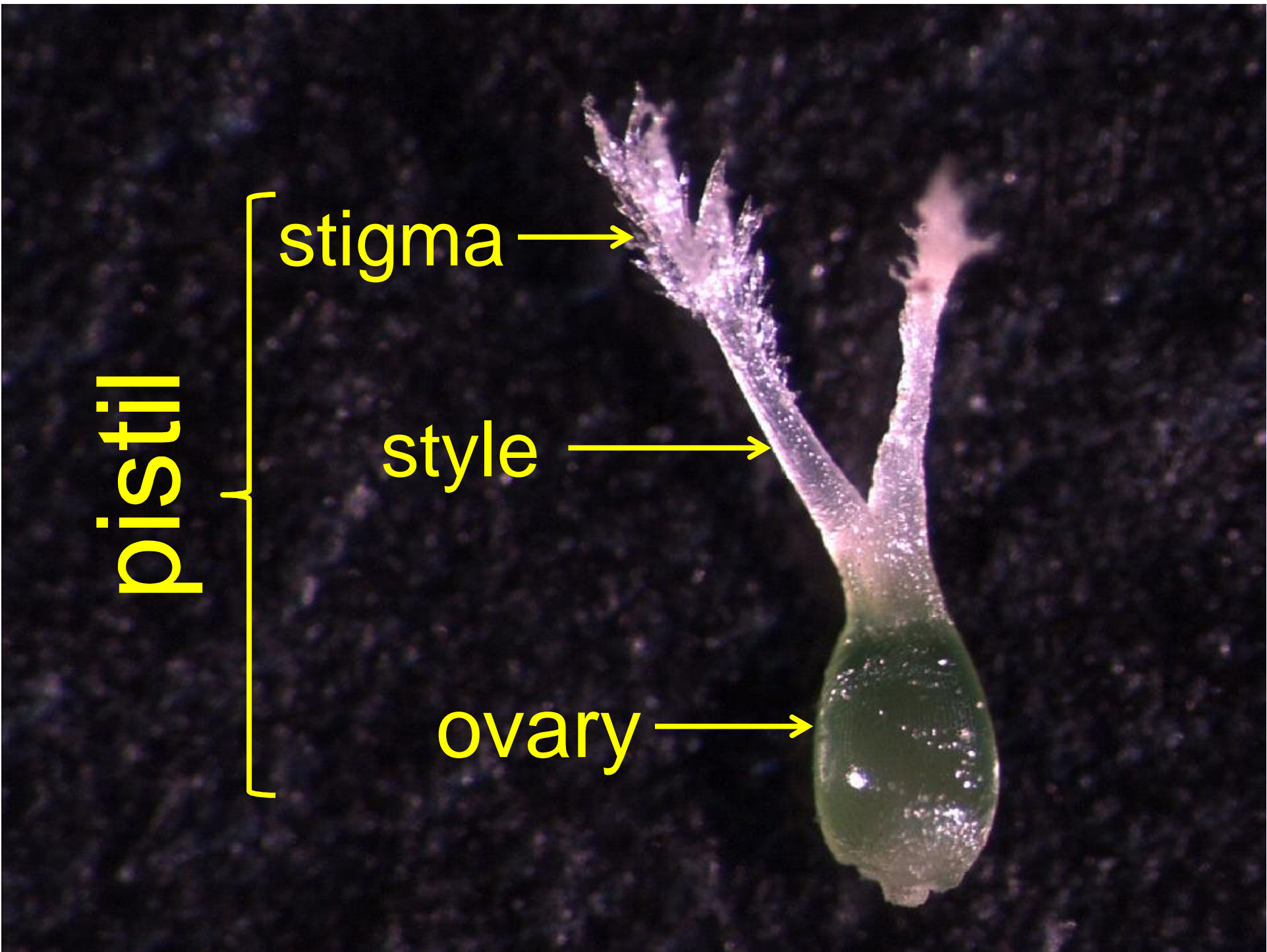
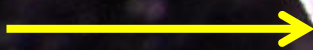
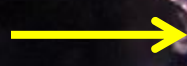


pistil

stigma

style

ovary



General Effects of Heat on Rice

- Poor germination
- Decrease in plant height
- Decrease in tillering
- Decrease in grain formation

From Nishiyama and Satake 1981

Optimal Temperature for Panicle Differentiation

64°F to 86°F

Panicle
Differentiation
or PD is
stage when
panicle
develops

Immature
panicle



Most Susceptible Stages

- Heading
- Booting

From Satake and Yoshida 1978

General Effects of Heat on Reproduction

- Albinism of panicles and spikelets
- Decrease in number of spikelets
- Sterility during flowering
- Lowering of ripening

From Shimizu and Kuno 1975

Albinism is
the absence
of chlorophyll
producing a
white
spikelet or
panicle



Normal Pollination and Fertilization

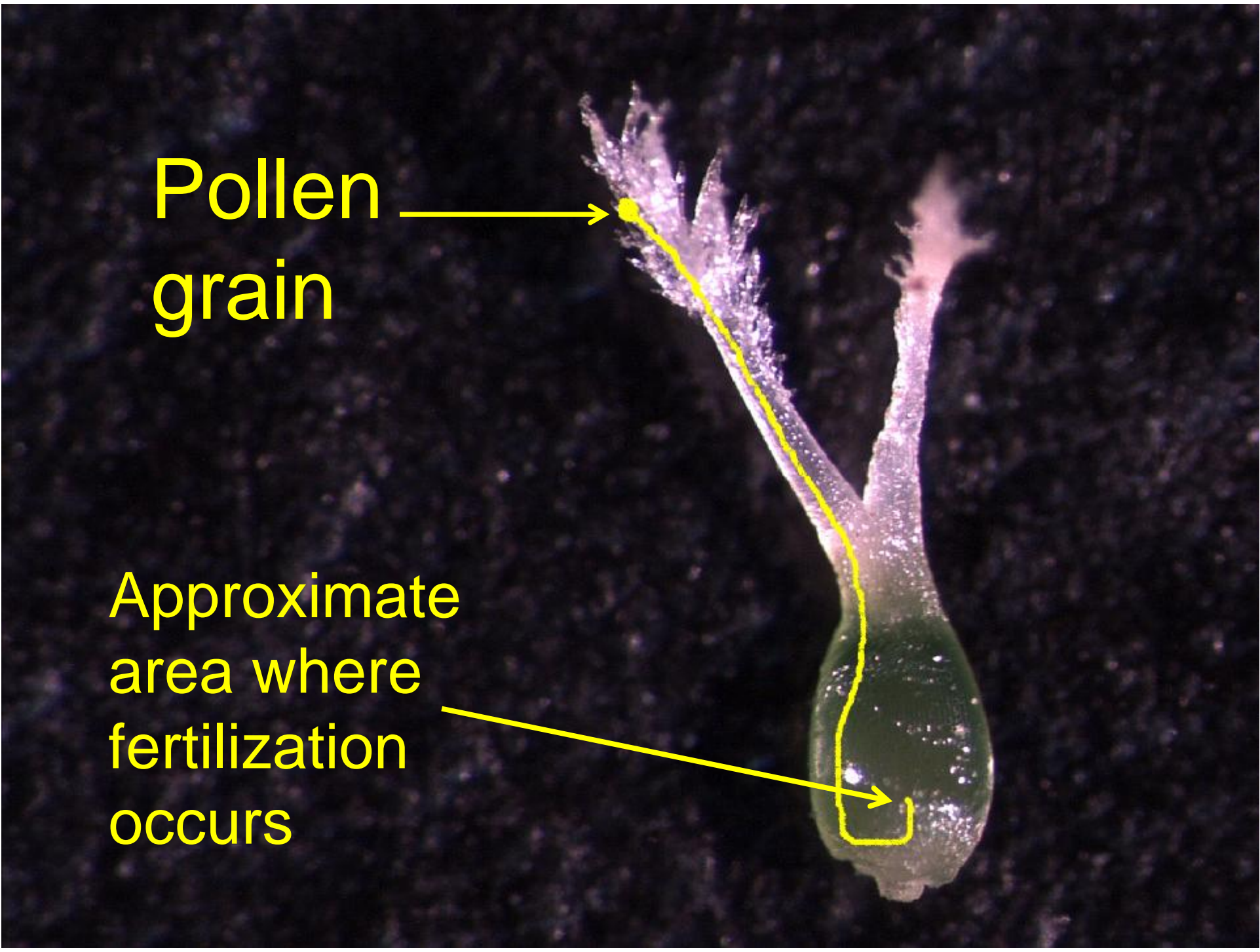
- Pollen tube extension to embryo sac – 30 minutes
- Fertilization complete 1.5 to 4 hours

From Cho 1956

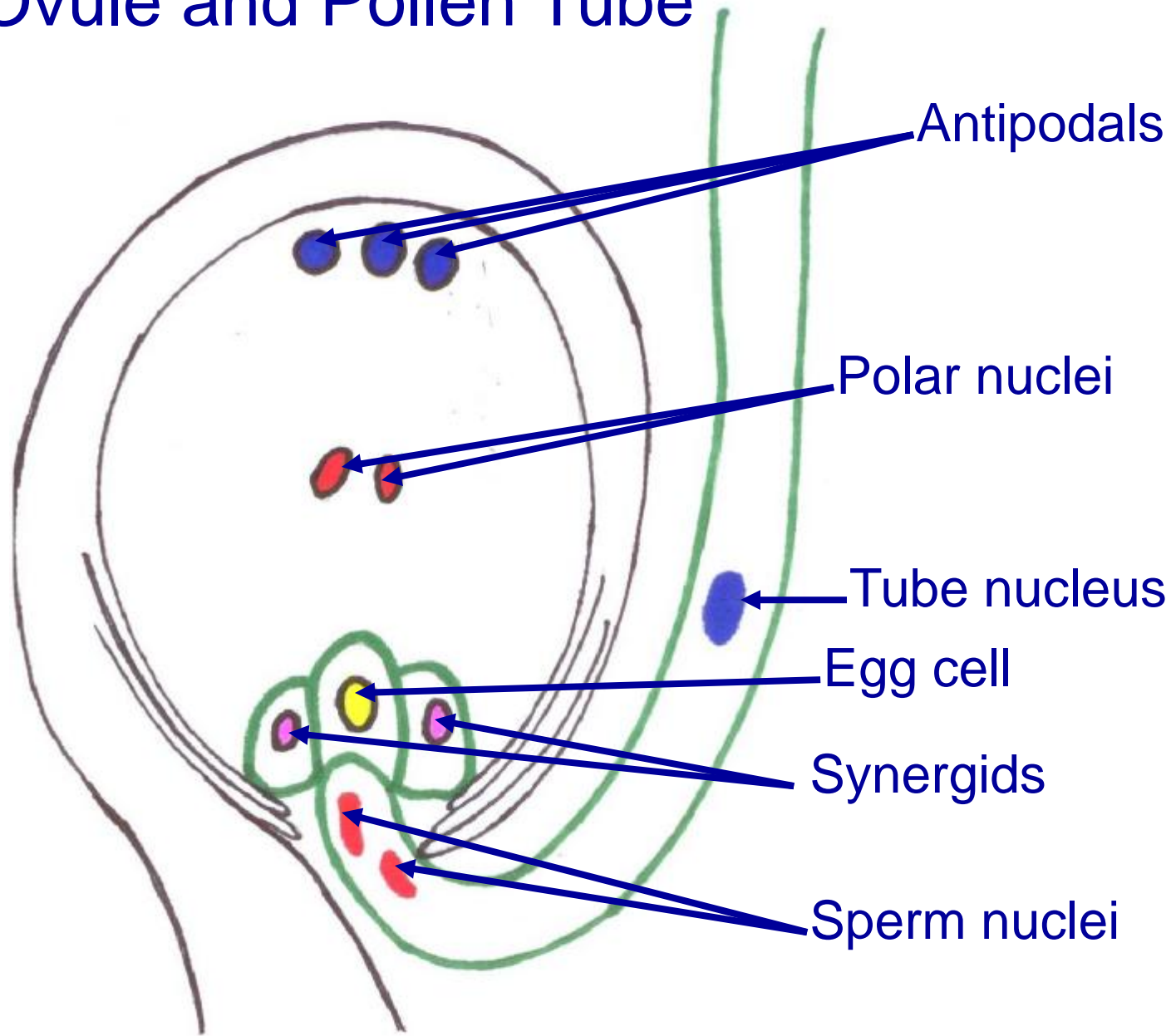
Pollen grain



Approximate area where fertilization occurs

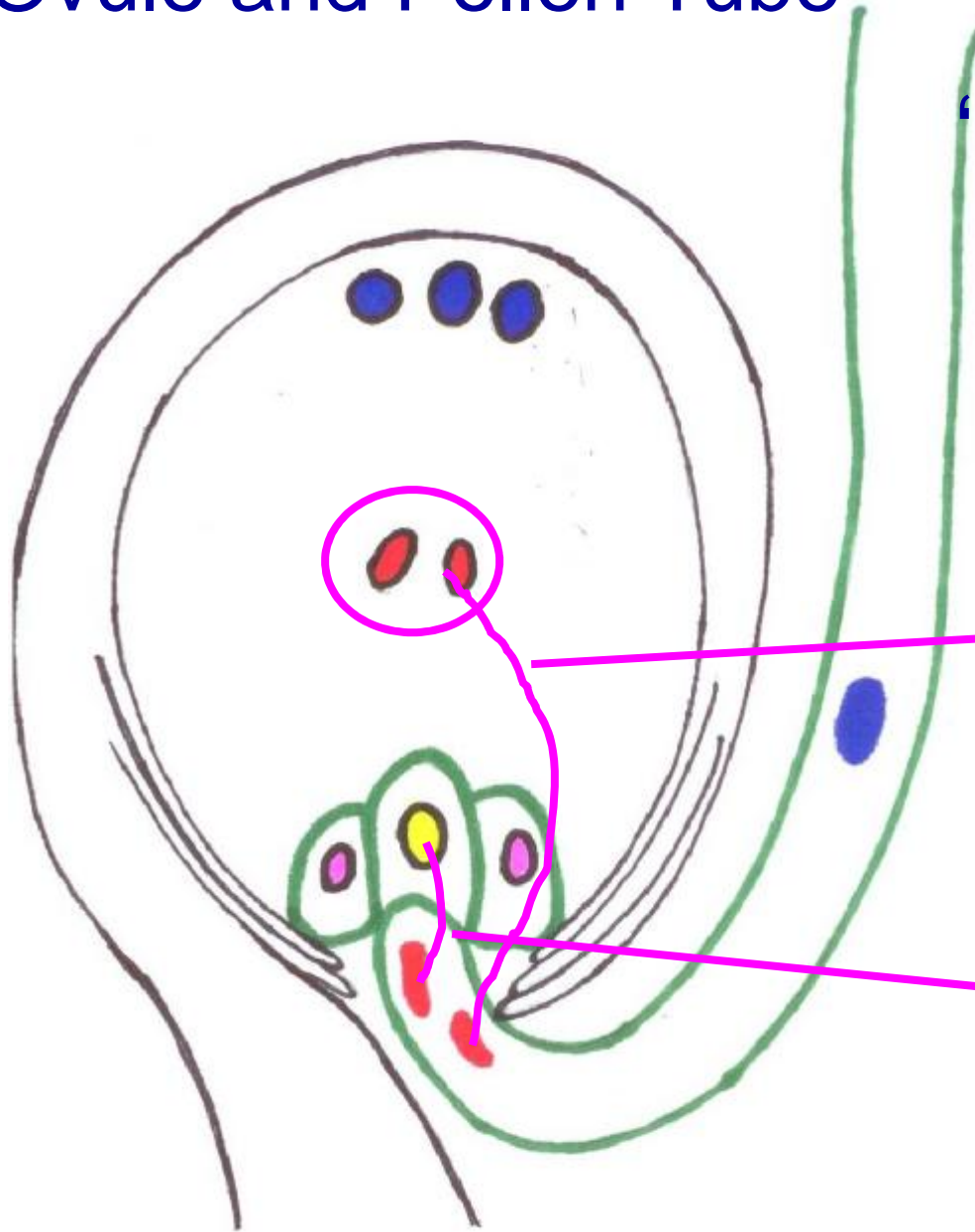


Ovule and Pollen Tube



Ovule and Pollen Tube

“Double Fertilization”



One sperm cell unites with the polar nuclei to form $3n$ endosperm

One sperm cell unites with egg cell to form zygote

Critical Temperature to Cause Sterility Depends Upon:

- Cultivar
- Growing conditions
- Duration of High Temperature

From Satake and Yoshida 1978

Critical Temperature to Cause Sterility by Cultivar

- Heat tolerant - 98.6°F
- Medium tolerant - 95°F
- Heat susceptible - 89.6°F

From Satake and Yoshida 1978

Critical Temperature and Duration to Cause Sterility by Cultivar

- Heat tolerant - 100°F for 4 hours
- Medium tolerant - 98°F for 2 hours or 95°F for 4 hours
- Heat susceptible - 95°F for 2 hours

From Satake and Yoshida 1978

Mechanisms of Sterility

- Pistil injury – egg cell does not develop?
- Stamen injury
 - Disturbed shedding of pollen grains
 - Reduced viability of pollen grains

From Satake and Yoshida 1978

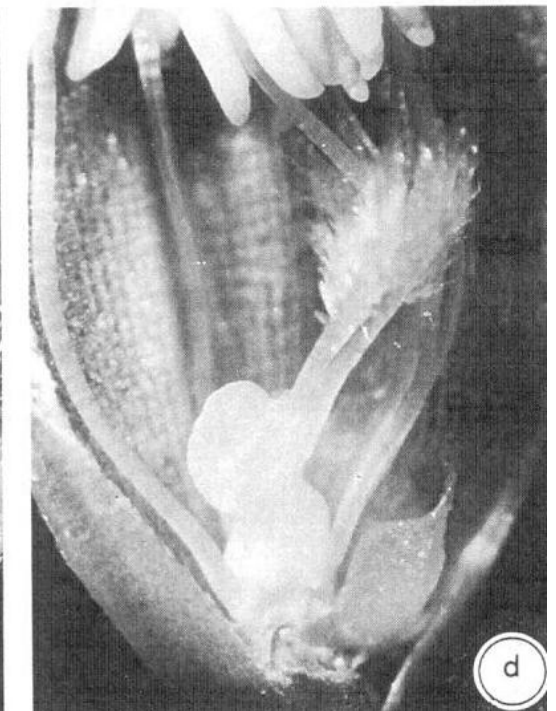
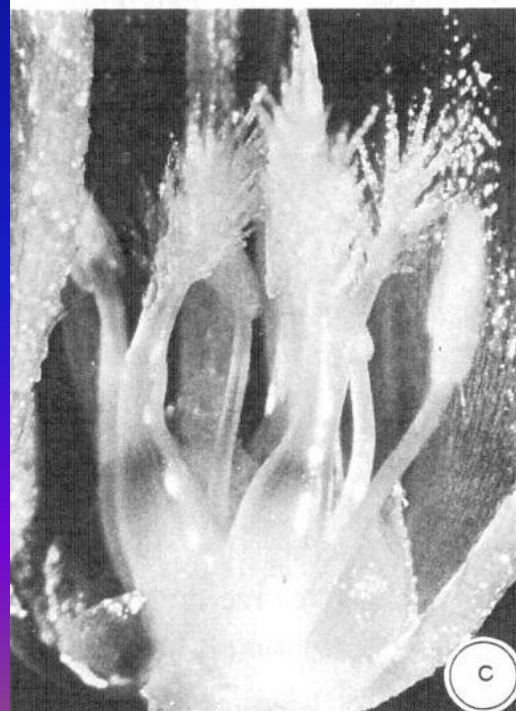
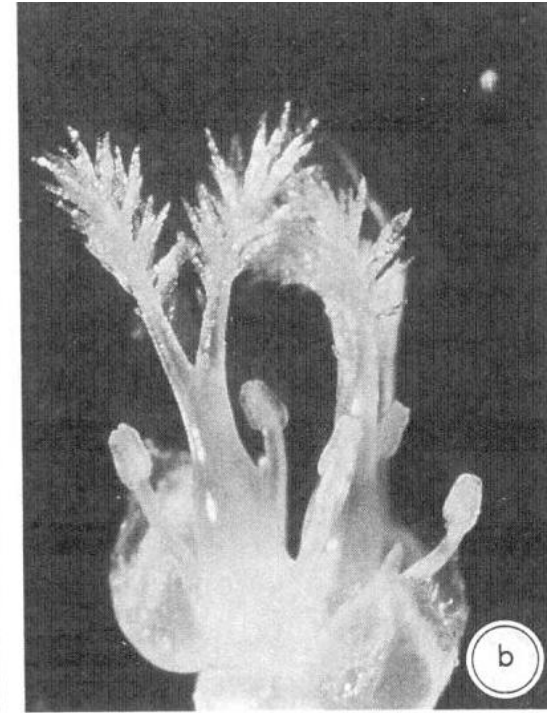
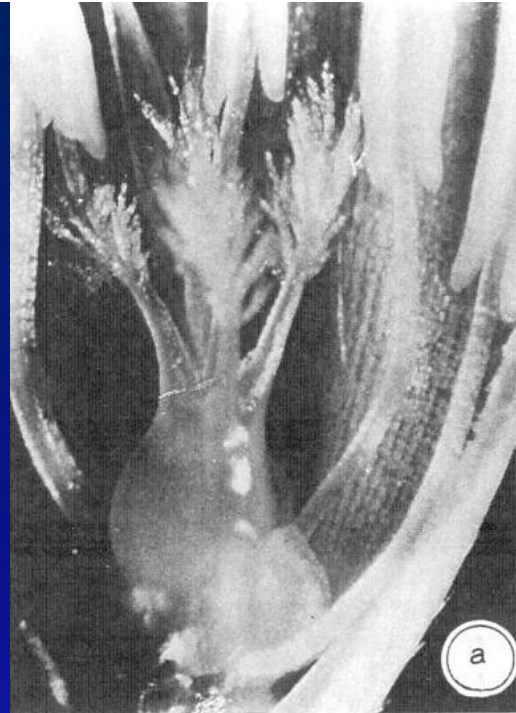
Flower Abnormalities

A. Stamens decrease,
stigmata increase

B and C. Stamens
decrease, differentiated
stamens stop growth,
two pistils develop

D. Tissue enlargement
in part of ovary

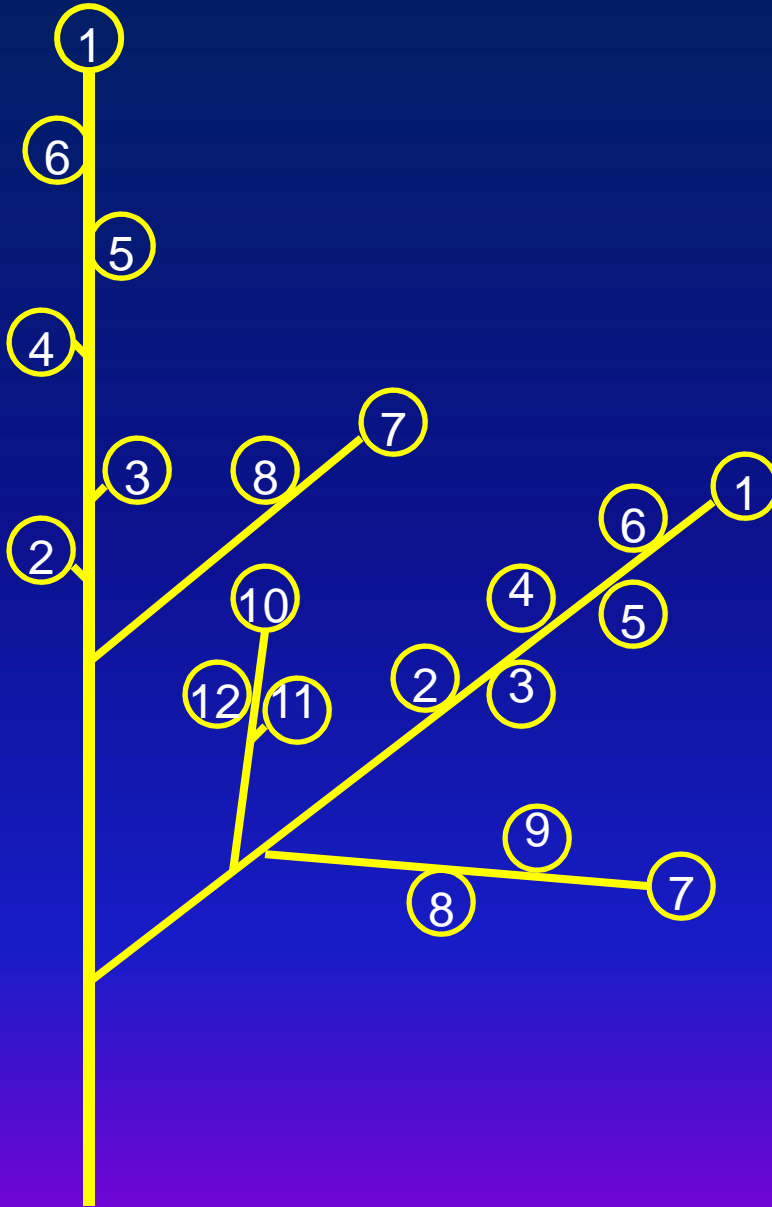
From Takeoka *et al.* 1988



Flowering Processes

- 6-7 days for all spikelets on panicle to emerge
- Normal flowering – spikelet opens before noon, anther dehisces, fertilization, glume closes
- Abnormal flowering – cloudy day, fertilization w/o spikelet opening
- Simultaneous flowering – several spikelets open at same time following unfavorable weather

Schematic
representation
of flowering
sequence in a
rice panicle



High Temperature Effects on Flowering

- Inferior spikelets – nutrient deficient
- Rate of translocation to superior spikelets slows
- Nutrient accumulation in inferior spikelets resumes

Temperature Effects on Yield

- High temperature reduces yield
 - Excessive energy consumption
 - Associated with respiration
- Greater the difference between daytime and night time temperatures – greater yield

Temperature Effects on Yield

- High temperature – more rapid starch accumulation
- High temperature – more rapid translocation of hydrocarbons

Starch Accumulation in Rice Grain

- Division and proliferation of endosperm cells complete 9-10 days after flowering
- Accumulation of reserve substances begins around 10th day of flowering

Starch Accumulation in Rice Grain

- Starch accumulates in short period
 - 5-6 days after flowering begins, rapid
 - 20 days after flowering begins, maximum
- Starch granules accumulate in amyloplasts
- Amyloplasts are plastids which fill endosperm cells

Temperature Effects on Chalk

- High night time temperatures most damaging
- High temperatures during grain filling causes rapid ripening

High Temperature Effects on Chalk

- More chalkiness on inferior grains
- Insufficient starch accumulation on out layers of endosperm

How to Breed for Heat Tolerance

- Increase true tolerance
 - Increase pollen grain shedding ability
 - Increase pollen grain germination
- Avoid heat
 - Select varieties that flower earlier in the morning

From Imaki *et al.* 1987

Science of the Rice Plant

Vol. 2 Physiology

edited by

Takane Matsuo

Kikuo Kumazawa

Kuni Ishihara

Hiroshi Hirata

1995

Johnny Saichuk

Rice Specialist

337-788-7547

337-849-6253

jsaichuk@agcenter.lsu.edu





