

# INDEX

## A

Abscisic acid (ABA) ..... 221, 222, 249  
 Acidic peptides ..... 27  
 Adenine N6-substituted organic molecules ..... 81  
 Adobe Illustrator ..... 88  
 Adobe Photoshop ..... 62, 88  
 AFM. *See* Atomic force microscopy (AFM)  
 Agar plates ..... 94  
 Alanine scanning technique ..... 25  
 Amino acid substitutions, peptides ..... 25  
 Analyze Cells 3D ..... 109–111  
 Antagonistic peptides ..... 25  
 Apical hook development ..... 1, 3, 5, 7  
   definition ..... 6  
   ethylene levels ..... 2  
   formation ..... 1  
   kinetic analysis ..... 6  
   materials and chemicals ..... 3–5  
   methods ..... 5–6  
   molecular pathways ..... 3  
   monitoring early phases ..... 7  
   phases ..... 1  
   real-time analysis ..... 2, 7  
*Arabidopsis* ..... 109, 232–234  
   liquid medium for ..... 23  
   solid medium for ..... 22–23  
   sterilization of seeds ..... 22  
   studies conducted in ..... 24  
 Arabidopsis histidine transfer proteins (AHP) ..... 82  
 Arabidopsis response regulator (ARR) ..... 82  
*Arabidopsis thaliana* ..... 9, 11–17, 29, 30, 47–49,  
   60, 69, 71, 82, 85, 92, 95, 125, 211, 252, 253  
   grafting ..... 9, 12  
   germination experiment ..... 58, 64  
   merits ..... 57  
   three-segment graft ..... 14–15  
   two segment shoot-root graft ..... 11–14  
   two-segment self-grafts ..... 16  
   two-shoot Y-graft ..... 16  
 Arduino ..... 37, 38, 43–45  
 Area under the curve (AUC) ..... 59, 68, 71  
 ARF5 ..... 136–138, 140, 142–143  
 ARFs. *See* Auxin response factors (ARFs)  
 Atomic force microscopy (AFM) ..... 125, 126, 128, 132

  cell wall elasticity ..... 128–129  
   data analysis ..... 129–131  
   preparation of cells ..... 128  
 Auto clustering ..... 113  
 Autocrine (self) signaling ..... 19  
 Automatic scoring ..... 58, 66, 70  
 Auxin ..... 2, 221, 222, 231, 249, 271–276, 278–281  
   binding ..... 160, 169  
   steady state assay ..... 275–276  
   transport ..... 207, 260  
   treatment ..... 75, 76  
 Auxin binding protein1 (ABP1) ..... 160, 207  
 Auxin response factors (ARFs) ..... 136, 137, 142–143  
 Axial sampling rate ..... 87

## B

Bezier curve ..... 105–108, 112  
 $\beta$ -Glucuronidase (GUS) ..... 73–78  
 BIACORE 2000 ..... 160, 162, 163, 174,  
   180, 187, 189, 190  
 BIAevaluation software ..... 174, 184, 188, 190  
 Binding site ..... 196  
 Biological assays ..... 24  
 Biotinylation ..... 262, 267, 269  
 Brassinosteroid insensitive 1 (BRI1) ..... 207, 209  
 Brassinosteroid receptor ..... 207  
 Brassinosteroids (BRs) ..... 249, 250  
 Bright yellow 2 (BY-2) cells ..... 125, 127, 128, 130, 131  
 Bright-field (BF) ..... 97  
 5-Bromo-4-chloro-3-indolyl-beta-D-glucuronide ..... 74  
 Budding yeast ..... 271, 281

## C

Calibration solution ..... 252  
 CCD scanner ..... 52  
 Cell Atlas 3D tools ..... 110  
 Cell clusters ..... 112–114  
 Cell data ..... 114, 115  
 Cell growth ..... 131  
 Cell type identification ..... 112–114, 117, 119, 122  
 Cell types ..... 111–112  
 Cell wall ..... 125, 128–131  
 Cell wall elasticity ..... 125, 128–129  
 Cells 3D ..... 109–111

Cell-sorting (3–4 h).....238–240  
 Chelex .....201, 202  
 Chimeric organisms.....9  
 ChIP. *See* Chromatin immunoprecipitation (ChIP)  
 Chromatin ..... 193–195, 198–200, 202  
   aliquot.....200  
   extraction .....193  
   fragmentation .....199–200  
   preparation.....198–199  
 Chromatin immunoprecipitation (ChIP) .....193, 195–197, 200, 202  
   principle.....195  
   workflow.....194  
 CK. *See* Cytokinin (CK)  
 Classical plant hormones .....19  
 Columella ..... 110, 114  
 Compound screen..... 159, 179, 180  
 Conducting germination tests .....32–33  
 Confocal laser scanning microscopy .....87–88  
 Confocal microscopy .....95, 135, 138, 143–145  
 Control folder.....116  
 Cortical cells..... 110, 114  
 Cotyledons ..... 9, 11, 13, 15–17  
 cRNA .....268  
   oocyte injection.....261, 263–264  
   vitro transcription .....260–261, 263  
 csv file.....122  
 Culturing plants .....49–51  
 Curve-fitting .....68  
 Cysteine-rich peptides.....20  
 Cytokinin (CKs).....81, 221, 222, 231, 234–236, 242, 249  
   CHASE.....82  
   class .....81  
   purification .....240–241  
   quantification.....241–242  
   signaling .....82  
   stimulus .....82

**D**

2,4-D auxin .....131  
 2D heatmap GUI.....112–114  
 3D CellAtlas ..... 100, 115–119  
   add-on .....100  
   Analyze Cells 3D .....109–111  
   *Arabidopsis* hypocotyl.....113  
   assign cell types.....111–112  
   assign columella .....114  
   assign cortical cells.....114  
   cell clusters.....112–114  
   displaying cell data.....115  
   examine vasculature .....114  
   merits.....100  
   sample for .....108–109

  saving and loading cell data .....114  
   statistical analysis  
     3D cell anisotropy..... 115–116  
     3D reporter abundance ..... 116–119  
     topological check .....114  
 3D cell anisotropy..... 100, 115–116  
 3D cell mesh.....105  
 3D data sets.....99  
 3D image analysis.....99–101  
 3D reporter analysis tool ..... 116–119  
 3D segmentation .....102–105  
 Data interpretation .....68  
 Data processing .....174–180  
 Data\_CI.csv file.....116  
 DBD. *See* DNA-binding domain (DBD)  
 DBP trays.....68  
 De-cross-linking..... 199, 201, 202  
 Degron peptide.....166–168, 170, 172, 174  
 Deoxyribonucleic acid (DNA)  
   fragments .....202  
   recovery.....201  
 Derivatization..... 223, 225, 228  
 Digital single-cell analysis ..... 100, 106, 111  
 Display cell data tool .....115  
 DNA-binding domain (DBD)..... 137, 142–143  
 Dose–response analysis.....24  
 Dot-PCB.....42  
 Double-transfected protoplasts.....141  
 Dropper tool.....104  
 DSMZ-German collection of microorganisms and cell cultures.....126

**E**

Efflux experiments.....264–265, 269  
 Elasticity..... 125, 128–129, 132  
 Endocrine (systemic) signaling.....19  
 Endoglycosidase H (Endo H) .....207, 209, 212–214, 218  
 Epitope gene .....195  
 Error limit ..... 110, 114  
*Escherichia coli* .....73  
 Ethereal diazomethane .....228  
 Ethylene ..... 221, 249  
 External hybrid (HyD) detectors.....144  
 Extra filtering software.....155

**F**

FACS. *See* Fluorescence-activated cell sorting (FACS)  
 False discovery rate (FDR) .....153  
 FIJI (ImageJ) .....48, 52  
 FLIM. *See* fluorescence lifetime imaging microscopy (FLIM)  
 Flow cytometry.....272, 273  
 FlowTime.....273  
 Fluorescence .....95, 97

microscopy.....82  
 proteins.....135, 138  
 reporters.....271, 272, 280  
 Fluorescence lifetime imaging microscopy  
 (FLIM).....91, 136–138, 140–145, 147  
 Fluorescence-activated cell sorting (FACS).....231–235,  
 238, 240, 242, 245, 246  
 Flux experiments .....262  
 Forceps .....10, 11, 13, 15–17  
 Formation phase.....2, 6  
 Förster resonance energy transfer (FRET).....135–137,  
 141–143, 145  
 FSC-A (Forward-scattered light) *vs.* SSC-A  
 (Side-scattered light) .....232  
 Fucose deficient plants.....214–216  
*fut11 fut12* mutant.....215

**G**

GA. *See* Gibberellins (GA)  
 GA-F1  
 application .....92  
 effects of light.....96  
 liquid work solution.....93  
 MS agar plates.....93  
 pattern .....92  
 roots.....94  
 stock solution.....93  
 Gas chromatography-mass spectrometry  
 (GC-MS) .....222, 225–226, 250  
 Gene expression.....196  
 Genome-wide association mapping.....50, 52–54  
 Genome-wide association studies (GWAS).....47, 48,  
 51–53  
 Germination score.....71  
 Germinator.....58–63, 67, 68  
 curve fitting .....59  
 experiment design.....59  
 image analysis.....59  
 Gibberellins (GAs).....91, 221, 222, 249  
 Glycoprotein.....206, 210, 211, 213, 214, 216–218  
 Glycosylation.....205  
 Golgi apparatus .....206, 214–216  
 Grafting.....9, 13  
 Green fluorescent protein (GFP) .....82, 87, 148,  
 153, 156, 232, 233, 273, 280  
 Group-specific parameters software .....155  
 Growing seedlings.....85  
 Growth analysis 3D tool.....116  
 GUS. *See*  $\beta$ -Glucuronidase (GUS)  
 GWAS. *See* Genome-wide association studies (GWAS)

**H**

Heatmaps .....117, 119  
 Hertzian model .....129

High-performance liquid chromatography  
 (HPLC).....26, 223  
 Histochemical staining.....73, 74, 76–79  
 Hormones  
 classical plant .....19  
 extraction .....252–254  
 mammalian models.....19  
 paracrine peptide .....19  
 receptors .....206, 207, 209, 210, 214  
 HPLC. *See* High-performance liquid chromatography  
 (HPLC)  
 Hybond membrane.....11–13, 17  
 Hydroxyprolination .....25  
 Hypocotyl.....1–3, 6, 11–17, 29, 30, 35

**I**

Identification and quantification software.....155  
 Image acquisition.....60–61, 64–65, 100–101, 140  
 Image analysis software .....58, 59, 61, 69, 101  
 ImageJ software .....59, 61, 62, 65–67, 69, 71, 74, 127  
 ImageJ-based quantification .....77–79  
 Imaris software .....88  
 Imbibition phase I .....70  
 Immunoblotting .....213–214, 262, 266  
 Immunoprecipitation (IP) .....147–151, 194, 200–201  
 chromatin beads.....200  
 de-cross-linking.....201  
 DNA recovery .....201  
 washes.....200–201  
 Import experiments .....265  
 Import export .....260  
 Indole acetic acid (IAA) .....126, 127, 129,  
 130, 271, 275, 279  
 Infrared light .....3–5  
 Internal standard solution.....251, 256, 257  
 Interstock graft. *See* Three-segment graft  
 IP. *See* Immunoprecipitation (IP)  
 Isothermal titration calorimetry (ITC).....160  
 ITK Smoothing Recursive Gaussian Blur .....103, 105  
 ITK Watershed Auto Seeded .....103

**J**

Jasmonates.....221, 222, 249, 250, 257

**K**

Karrikins (KARs) .....30–35  
*Arabidopsis*.....29–35  
 germination tests .....32–33  
 hypocotyl elongation assay.....30, 33–35  
 methods .....31, 32  
 seed germination.....30–32  
 Kifunensine treatment .....213–214, 217  
 Kinetic analysis dialogue box.....190  
 Kinetics.....159, 180–187

**L**

Laplacian smoothing .....121  
 l-arabinylation .....25  
 LC-ESI-MS/MS .....251  
 Limits of detection (LOD) .....256, 257  
 Limits of quantification (LOQ) .....256  
 Linked reactions .....184  
 Liquid chromatography-mass spectrometry  
   (LC-MS) .....222, 250, 254  
 Liquid growth medium .....83  
 Liquid scintillation .....262, 265  
 Load heat map .....119  
 Logarithmic transformation software .....155  
 Luciferase (LUC) reporters .....82

**M**

Mammalian models .....19  
 Manhattan plot .....53  
 Marching Cubes 3D .....105, 106  
 Mass spectrometry (MS) .....154, 222, 226, 233,  
   241, 250, 253, 255, 257  
   sample preparation .....151–152  
   tandem .....152  
 Mass spectroscopy (MS) .....149–150, 152  
 Mass transport limitation .....190  
 Matlab .....127  
 MaxQuant protein identification .....149, 152–154, 158  
 MCP-PMT detectors .....144  
 Melatonin (MEL) .....249  
 Micropurification (microSPE) .....234, 240  
 Microsoft Excel 2003 .....62  
 Microsoft Excel 2010 .....62  
 Min voxels .....105  
 Mis-annotated cells .....114  
 Misc. software .....155  
 Molecular biology .....92  
 Molecular pathways .....3  
 MorphoGraphX .....100–105, 107–109, 117, 119–121  
 Mounting medium .....84  
 MS medium .....85  
 MSBY media .....126, 128  
 Multiple reaction monitoring (MRM) .....241, 250, 254  
 Multi-StageTips .....236, 244

**N**

N-acetylglucosamine (GlcNAc) .....206  
 NetNGlyc .....209  
 N-glycosylation .....205–207, 209–211, 213, 216–218

**O**

O-glycosylation .....206  
 Oligosaccharyltransferase (OST) .....206, 211, 213,  
   214, 216, 217

One cell sorting experiment (3–4 h) .....237–238  
 One sorting experiment .....237  
 Opening phase .....2, 6  
 Optimal ImageJ .....65–66  
 Output folder .....116  
 Output type .....116  
 Output\_CI.csv file .....119

**P**

Paracrine (adjacent/nearby tissue) signaling .....19  
 Paracrine peptide hormones .....19  
 Peptides .....19, 20  
   acidic .....27  
   amino acid monomers .....20  
   analysis of .....21  
   antagonistic .....25  
   basic .....27  
   cysteine-rich .....20  
   hormone .....19  
   PTMPs (*see* Posttranslationally modified peptides  
     (PTMPs))  
     purity .....26  
     signal .....19  
     uncharged .....27  
     use of synthetic .....20  
 Petiole .....13, 15, 16  
 Petri dishes .....4, 5, 11, 12, 236  
 Phosphate-buffered saline (PBS) .....242  
 Phytochrome interacting factors (PIFs) .....193  
 Phytohormone auxin .....125  
 Phytohormones .....19, 222  
 Pipette cookbook .....268  
 Plant development .....81  
 Plant hormones .....221, 222, 249, 250, 256, 257  
 Plant material .....148–150, 156, 214  
 Plant tissue .....201, 224, 257  
 Plasma membrane proteins .....266–267  
 PNGase F digestion .....214–216  
 Posttranslationally modified peptides (PTMPs) .....20–26  
   applications .....24–25  
     amino acid substitutions .....25  
     biological assay .....24  
     homologous signaling modules .....24  
     modification, peptides .....25  
   caveats .....25–26  
     contamination .....26  
     nonspecific effects .....25–26  
   functional analysis of .....20  
   materials .....21  
     analysis, peptide effect .....21  
     reconstitution and dilution, peptide .....21  
   methods .....21–24  
     *Arabidopsis* .....22–23  
     crop plants .....23

direct application .....23–24  
 dose–response analysis .....24  
 initial reconstitution and dilution .....21–22  
 wheat/tomato/oilseed rape/*Brachypodium*  
 seeds .....22  
 Preselect cluster .....113  
 Primer design .....196  
 Protein complex identification .....148, 156  
 Protein–protein interaction .....135, 137,  
 141–143, 147  
 Proteins .....25  
 Proteolytic cleavage .....20  
 Protoplasts .....232–235, 237–241, 244–247  
 isolation .....138–139  
 transfection .....139

**Q**  
 Quantitative PCR (qPCR) .....201

**R**  
 Radioactive substance  
 efflux experiments .....264–265  
 flux experiments .....262  
 import experiments .....265  
 Region of interest (ROI) .....141  
 Replace NaNs software .....155  
 Response units (RU) .....188, 189  
 R-language .....274  
 Root traits quantification .....50, 52  
 Roots .....237, 238, 245  
 Rotary shaker  
*Arabidopsis* seeds .....22  
 wheat/tomato/oilseed rape/*Brachypodium* seeds .....22

**S**  
*Saccharomyces cerevisiae* .....271  
 Salicylic acid .....221–227, 249  
 Sample preparation mass spectroscopy .....149–152  
 Saturation channel .....74  
 Save cell data .....114  
 Seed dormancy .....30  
 Seed germination .....57, 63–67  
 assays .....60  
 color thresholds .....65  
 experiment  
 analyze .....66–67  
 pictures .....65  
 preparation .....63  
 start .....63–64  
 Seed sterilization .....85, 93–94  
 Seedling growth .....74–76  
 Seedling preparation .....94–95  
 Segmentation threshold .....120  
 Segmented organ mesh .....119–120

Select bad cells .....111  
 Shoot apical meristems .....84, 86  
 Signal sequences .....19, 111, 112  
 Signaling peptide .....19  
 Silique age .....89  
 Sliding average .....115, 116  
 Small white cross .....112  
 Smooth passes .....105  
 Solid growth medium .....83  
 Solid-phase extraction (SPE) .....223–225, 227, 234  
 Sonication device .....199, 202  
 Sow seeds .....94  
 SPCImage .....140  
 Specimen preparation .....95  
 Spectrum digital camera .....3  
 SPR. *See* Surface plasmon resonance (SPR)  
 Stable isotope .....222–224, 226  
 StageTip technology .....234  
 Steady-state assay .....275–276, 279–280  
 Steady-state data .....279–280  
 Stereomicroscope .....86  
 Streptavidin agarose .....262, 266, 269  
*stt3a* mutant .....211–214, 217  
*stt3b* mutant .....217  
 Surface mesh  
 create .....105  
 trim .....105  
 Surface plasmon resonance (SPR) .....135, 159, 160,  
 162, 164, 170, 188  
 setup .....162, 170–174  
 thermodynamics .....187  
 Synthetic biology .....273  
 Synthetic complete (SC) .....274  
 Synthetic peptide .....27  
*Arabidopsis* .....22–23  
 crop plants .....23  
 effect on plants .....24  
 purchasing .....26  
 usage .....20  
 Synthetic reporter .....82

**T**  
 Tandem mass spectrometry .....148, 149, 152,  
 155, 216, 222  
 TCS. *See* Two-component signalling (TCS)  
*TCSn* .....82, 83, 85, 87, 88  
*GFP* expression .....82, 83,  
 85, 87, 88  
 TCSPC .....144  
 Tetracyclic diterpene carboxylic acids .....91  
 Three-segment graft .....10, 14–15  
 Threshold volume .....110, 114  
 Threshold wall area .....110  
 Time course data .....274–280

Time-lapse plant phenotyping ..... 37, 38, 42–45  
 control unit construction .....40–41  
 imaging .....38–39  
 microcontroller ..... 38, 42–43  
 rotating stage .....38  
 rotor construction .....39  
 software .....38  
 stage .....41–42  
 tools .....39  
 uploading Arduino script .....43–44  
 ways to use ..... 44  
 Tissue harvesting .....238  
 Transcription factors .....193, 201  
 Transcriptional fusions .....24  
 Transfection protocol .....138  
 Transient expression vectors .....138  
 Transport inhibitor resistant 1 (TIR1) ..... 160, 162, 191  
 Transport proteins .....259  
 Treatment folder .....116  
 Triple-quadrupole mass spectrometers .....226  
*T*-test software .....155  
 Tunicamycin treatment .....217  
 Two segment shoot-root graft .....11–14  
 Two-component signalling (TCS) .....82  
 LUC reporters .....82  
 reporter .....82  
 Two-electrode voltage clamp (TEVC) .....260  
 Two-segment self-grafts ..... 15, 16  
 Two-shoot Y-graft .....16  
 Tyrosine sulfation .....25

**U**

UHPLC-MS/MS method ..... 233, 234,  
 236–237, 242  
 Ultra Fine Micro Knife .....16  
 Ultrahigh-performance liquid chromatography–electrospray  
 ionization tandem mass spectrometry (UPLC/  
 ESI-MS/MS) .....253, 255  
 Ultrahigh-performance liquid chromatography–electrospray  
 tandem quadrupole mass spectrometry  
 (UHPLC-MS/MS) .....254

**V**

Vasculature ..... 110, 114

**W**

Western blotting .....268  
 Whatman circles .....11, 12

**X**

*Xenopus laevis* oocytes ..... 259, 260,  
 262–269

**Y**

Y-Dim ..... 111, 112  
 Yellow fluorescent protein (YFP) .....273, 280  
 Y-grafts .....10, 15, 16  
 Young's modulus (EA) .....129, 130  
 YPDA agar plates .....272, 273