

## The identification tool *Digiphyll* – a short introduction

The identification tool of *Digiphyll* is based on check-boxes assigned to a number of leaf morphological characters (or traits). Individual leaf characters are defined systematically based on qualitative and quantitative properties (character states). These character states can be simply binary or hierarchically nested. The identification process in *Digiphyll* follows these levels via hierarchical check boxes: if the state of a leaf character is identified for the considered fossil, the corresponding check-box is clicked.

The cuticle is the waxy layer extruded by and covering the epidermis cells. This layer, when isolated and prepared, represents a cast of the epidermis and provides the appearance of the epidermis cells and the stomatal apparatus.

In the following, cuticle characters are divided into three groups.

**C:** characters of the **adaxial cuticle** (= upper leaf side)

**D:** characters of the **mesophyll** (leaf tissue)

**E:** characters of the **abaxial cuticle** (lower leaf side).

The character system used in *Digiphyll* follows vastly *D. Dilcher (1974): Approaches to the identification of angiosperm leaf remains. - The Botanical Review, 40(1): 1–157*. The concept of the identification process applied in *Digiphyll* will be summarised in the following. For a more detailed description of the traits, see *Dilcher (1974)*.

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### C. Adaxial cuticle

All treated adaxial cuticle traits are split up into **13** sections. Each of these sections contains one or more characters with several character states:

- C-1. Cuticle thickness
- C-2. Cuticle anticline
- C-3. Cuticle anticline-course
- C-4. Cuticle cell surface
- C-5. Cuticle surface ornamentation
- C-6. Cuticle trichome
- C-7. Cuticle trichome base
- C-8. Cuticle trichome base cells
- C-9. Cuticle trichome base poral rim
- C-10. Cuticle trichome base foot
- C-11. Cuticle trichome stalk
- C-12. Cuticle trichome head
- C-13. Cuticle epidermal secretory cells

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#### C-1. Adaxial cuticle thickness

Describes the thickness of the cuticle, and is based upon sections and/or preparation, handling and general impression.

#	Code	Character State	Description
1	C-1.1	delicate	The cuticle thickness is rather delicate.
2	C-1.2	medium	The cuticle thickness is medium.
3	C-1.3	thick	The cuticle is thick.

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## C-2. Adaxial cuticle anticline

Describes the appearance of the anticlines.

#	Code	Character State	Description
1	C-2.1	smooth	The anticlines are even.
2	C-2.2	pitted	The anticlines show regular or irregular thickenings.

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## C-3. Adaxial cuticle anticline-course

Describes the cell outline of the epidermis cells.

#	Code	Character State	Description
1	C-3.1	straight	The cells show straight outlines and angular corners.
2	C-3.2	rounded	Cell outlines and corners are more or less rounded.
3	C-3.3	undulate	The anticlines are wavy.
4	C-3.3.1	> U-shaped	The undulation of the anticlines is U-shaped.
5	C-3.3.2	> V-shaped	The undulation of the anticlines is V-shaped.
6	C-3.3.3	> Omega-shaped	The undulation of the anticlines is shaped like an “Omega”.

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## C-4. Adaxial cuticle cell surface

Describes the surface profile of the epidermis cells.

#	Code	Character State	Description
1	C-4.1	even	The cell surface is even.
2	C-4.2	domed	The cell surface is domed.
3	C-4.3	papillate	The cell surface shows papillae.

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## C-5. Adaxial cuticle surface ornamentation

Describes presence and structure of epidermal cell surface ornamentations.

#	Code	Character State	Description
1	C-5.1	smooth	The surface is smooth – no structures present.
2	C-5.2	striate	The surface shows narrow grooves.
3	C-5.3	wrinkled	The surface shows wrinkles.
4	C-5.4	granular	The surface has a granular appearance.

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### C-6. Adaxial cuticle trichome

Describes whether trichomes and glandular trichomes are present, and – if present – their arrangement and structure.

#	Code	Character State	Description
1	C-6.1	absent	No trichomes are present.
2	C-6.2	present	Trichomes are visible.
3	C-6.2.1	> single	Trichomes are not arranged in groups.
4	C-6.2.2	> in tufts	Trichomes stand in groups, tightly arranged to each other.
5	C-6.2.3	> one-celled	Trichomes consist of one cell only.
6	C-6.2.4	> pluri or multicellular	Trichomes consist of more than one cell.

### C-7. Adaxial cuticle trichome base

Describes the position of the trichome base relative to the epidermal surface.

#	Code	Character State	Description
1	C-7.1	raised	Trichome base is elevated above the cuticular surface.
2	C-7.2	at the epidemis level	Trichome base is located at the level of the cuticular surface.
3	C-7.3	sunken	Trichome base is sunken below the cuticular surface.

### C-8. Adaxial cuticle trichome base cells

Describes the characters of the base cells of the trichomes.

#	Code	Character State	Description
1	C-8.1	unmodified	Base cells show no obvious modification.
2	C-8.2	modified	Base cells show special features.
3	C-8.2.1	> thickened	Base cells show thickened cell walls.
4	C-8.2.2	> unthickened	Base cell walls as in other cells.
5	C-8.2.3	> radially elongated	Base cells are radially elongated.
6	C-8.2.4	> radially not elongated	Base cells are not radially elongated.

### C-9. Adaxial cuticle trichome base poral rim

Describes the thickness of the rim around the base of the trichome.

#	Code	Character State	Description
1	C-9.1	thickened	Poral rim is thickened.
2	C-9.2	unthickened	Poral rim is not thickened.

### C-10. Adaxial cuticle trichome base foot

Describes the number of cells which compose the foot of the trichome base.

#	Code	Character State	Description
1	C-10.1	one-celled	Trichome base foot consists of one cell.
2	C-10.2	two-celled	Trichome base foot consists of two cells.
3	C-10.3	more than two cells	Trichome base foot consists of more than two cells.

### C-11. Adaxial cuticle trichome stalk

Describes the number of cells which compose the stalk of the trichome.

#	Code	Character State	Description
1	C-11.1	one-celled	Trichome stalk consists of one cell.
2	C-11.2	two-celled	Trichome stalk consists of two cells.
3	C-11.3	more than two cells	Trichome stalk consists of more than two cells.

### C-12. Adaxial cuticle trichome head

Describes the trichome head or tip.

#	Code	Character State	Description
1	C-12.1	simple	Trichome head is simple.
2	C-12.2	in tufts	Trichome head forms a tuft.
3	C-12.3	one celled	Trichome head consists of one cell only.
4	C-12.3.1	> linear (flagelliform)	Trichome head cell has a linear shape.
5	C-12.3.1.1	>> short	Trichome head cell is short (< 30 $\mu$ m).
6	C-12.3.1.2	>> medium	Trichome head cell is medium long (30 $\mu$ m < x < 60 $\mu$ m).
7	C-12.3.1.3	>> long	Trichome head cell is long (> 60 $\mu$ m).
8	C-12.3.2	> club-shaped	Trichome head cell is club-shaped.
9	C-12.3.3	> globular	Trichome head cell has a globular shape.
10	C-12.3.4	> peltate	Trichome head cell is shield-shaped.
11	C-12.3.5	> other	Trichome head cell has another shape.
12	C-12.4	pluricellular	Trichome head consists of more than one cell.
13	C-12.4.1	> elongated	Trichome head cells are elongated.
14	C-12.4.2	> club-shaped	Trichome head cells are club-shaped.
15	C-12.4.3	> globular	Trichome head cells have a globular shape.
16	C-12.4.4	> peltate	Trichome head cells are shield-shaped.
17	C-12.4.5	> other	Trichome head cells have another shape.

### C-13. Adaxial cuticle epidermal secretory cells

Describes whether secretory cells are present in the epidermis.

#	Code	Character State	Description
1	C-13.1	present	Secretory cells are present.
2	C-13.2	absent	Secretory cells are absent.

## D. Mesophyll

Only one character is considered for the leaf ground tissue, the mesophyll.

### D-1. Mesophyll secretory cells

Describes the absence/presence of secretory cells within the mesophyll, and their appearance.

#	Code	Character State	Description
1	D-1.1	absent	Secretory cells are absent.
2	D-1.2	present	Secretory cells are present.
3	D-1.2.1	> sporadic	Secretory cells occur sporadically.
4	D-1.2.1.1	>> shape globular	Shape of secretory cells is globular.
5	D-1.2.1.2	>> elongated	Shape of secretory cells is elongated.
6	D-1.2.1.3	>> irregular	Shape of secretory cells is irregular.
7	D-1.2.2	> dense	Density of secretory cells is high.
8	D-1.2.2.1	>> shape globular	Shape of secretory cells is globular.
9	D-1.2.2.2	>> elongated	Shape of secretory cells is elongated.
10	D-1.2.2.3	>> irregular	Shape of secretory cells is irregular.

## E. Abaxial cuticle

The abaxial cuticle characters are subdivided into 21 sections. Each of these sections contains one or more characters with several character states:

- E-1. Cuticle thickness
- E-2. Cuticle anticline
- E-3. Cuticle anticline-course
- E-4. Cuticle cell surface
- E-5. Cuticle surface ornamentation
- E-6. Cuticle trichome
- E-7. Cuticle trichome base
- E-8. Cuticle trichome base cells
- E-9. Cuticle trichome base poral rim
- E-10. Cuticle trichome base foot
- E-11. Cuticle trichome stalk
- E-12. Cuticle trichome head
- E-13. Cuticle epidermal secretory cells
- E-14. Cuticle stomatal complex type
- E-15. Cuticle stoma orientation
- E-16. Cuticle stoma distribution

- E-17. Cuticle stoma position relative to epidermis
- E-18. Cuticle stoma shape
- E-19. Cuticle guard cells
- E-20. Cuticle stomatal ledges
- E-21. Cuticle front cavity

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### E-1. Abaxial cuticle thickness

Describes the thickness of the cuticle, and is based upon sections and/or preparation, handling and general impression.

#	Code	Character State	Description
1	E-1.1	delicate	The cuticle thickness is rather delicate.
2	E-1.2	medium	The cuticle thickness is medium.
3	E-1.3	thick	The cuticle is thick.

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### E-2. Abaxial cuticle anticline

Describes the appearance of the anticlines.

#	Code	Character State	Description
1	E-2.1	smooth	The anticlines are even.
2	E-2.2	pitted	The anticlines show regular or irregular thickenings.

---

### E-3. Abaxial cuticle anticline-course

Describes the cell outline of the epidermis cells.

#	Code	Character State	Description
1	E-3.1	straight	The cells show straight outlines and angular corners.
2	E-3.2	rounded	Cell outlines and corners are more or less rounded.
3	E-3.3	undulate	The anticlines are wavy.
4	E-3.3.1	> U-shaped	The undulation of the anticlines is U-shaped.
5	E-3.3.2	> V-shaped	The undulation of the anticlines is V-shaped.
6	E-3.3.3	> Omega-shaped	The undulation of the anticlines is shaped like an “Omega”.

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### E-4. Abaxial cuticle cell surface

Describes the surface profile of the epidermis cells.

#	Code	Character State	Description
1	E-4.1	even	The cell surface is even.

#	Code	Character State	Description
2	E-4.2	domed	The cell surface is domed.
3	E-4.3	papillate	The cell surface shows papillae.

### E-5. Abaxial cuticle surface ornamentation

Describes presence and structure of epidermal cell surface ornamentations.

#	Code	Character State	Description
1	E-5.1	smooth	The surface is smooth – no structures present.
2	E-5.2	stiate	The surface shows narrow grooves.
3	E-5.3	wrinkled	The surface shows wrinkles.
4	E-5.4	granular	The surface has a granular appearance.

### E-6. Abaxial cuticle trichome

Describes whether trichomes and glandular trichomes are present, and – if present – their arrangement and structure.

#	Code	Character State	Description
1	E-6.1	absent	No trichomes are present.
2	E-6.2	present	Trichomes are visible.
3	E-6.2.1	> single	Trichomes are not arranged in groups.
4	E-6.2.2	> in tufts	Trichomes stand in groups, tightly arranged to each other.
5	E-6.2.3	> one-celled	Trichomes consist of one cell only.
6	E-6.2.4	> pluri or multicellular	Trichomes consist of more than one cell.

### E-7. Abaxial cuticle trichome base

Describes the position of the trichome base relative to the epidermal surface.

#	Code	Character State	Description
1	E-7.1	raised	Trichome base is elevated above the cuticular surface.
2	E-7.2	at the epidemis level	Trichome base is located at the level of the cuticular surface.
3	E-7.3	sunken	Trichome base is sunken below the cuticular surface.

### E-8. Abaxial cuticle trichome base cells

Describes characters of the base cells of the trichomes.

#	Code	Character State	Description
1	E-8.1	unmodified	Base cells show no obvious modification.
2	E-8.2	modified	Base cells show special features.
3	E-8.2.1	> thickened	Base cells show thickened cell walls.
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5	E-8.2.3	> radially elongated	Base cells are radially elongated.
6	E-8.2.4	> radially not elongated	Base cells are not radially elongated.

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### E-9. Abaxial cuticle trichome base poral rim

Describes the thickness of the rim around the base of the trichome.

#	Code	Character State	Description
1	E-9.1	thickened	Poral rim is thickened.
2	E-9.2	unthickened	Poral rim is not thickened.

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### E-10. Abaxial cuticle trichome base foot

Describes the number of cells which compose the foot of the trichome base.

#	Code	Character State	Description
1	E-10.1	one-celled	Trichome base foot consists of one cell.
2	E-10.2	two-celled	Trichome base foot consists of two cells.
3	E-10.3	more than two cells	Trichome base foot consists of more than two cells.

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### E-11. Abaxial cuticle trichome stalk

Describes the number of cells which compose the stalk of the trichome.

#	Code	Character State	Description
1	E-11.1	one-celled	Trichome stalk consists of one cell.
2	E-11.2	two-celled	Trichome stalk consists of two cells.
3	E-11.3	more than two cells	Trichome stalk consists of more than two cells.

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### E-12. Abaxial cuticle trichome head

Describes the trichome head or tip.

#	Code	Character State	Description
1	E-12.1	simple	Trichome head is simple.
2	E-12.2	in tufts	Trichome head forms a tuft.



#	Code	Character State	Description
3	E-12.3	one celled	Trichome head consists of one cell only.
4	E-12.3.1	> linear (flagelliform)	Trichome head cell has a linear shape.
5	E-12.3.1.1	>> short	Trichome head cell is short (< 30µm).
6	E-12.3.1.2	>> medium	Trichome head cell is medium long (30µm < x < 60µm).
7	E-12.3.1.3	>> long	Trichome head cell is long (> 60µm).
8	E-12.3.2	> club-shaped	Trichome head cell is club-shaped.
9	E-12.3.3	> globular	Trichome head cell has a globular shape.
10	E-12.3.4	> peltate	Trichome head cell is shield-shaped.
11	E-12.3.5	> other	Trichome head cell has another shape.
12	E-12.4	pluricellular	Trichome head consists of more than one cell.
13	E-12.4.1	> elongated	Trichome head cells are elongated.
14	E-12.4.2	> club-shaped	Trichome head cells are club-shaped.
15	E-12.4.3	> globular	Trichome head cells have a globular shape.
16	E-12.4.4	> peltate	Trichome head cells are shield-shaped.
17	E-12.4.5	> other	Trichome head cells have another shape.

### E-13. Abaxial cuticle epidermal secretory cells

Describes whether secretory cells are present in the epidermis.

#	Code	Character State	Description
1	E-13.1	present	Secretory cells are present.
2	E-13.2	absent	Secretory cells are absent.

### E-14. Abaxial cuticle stomatal complex type

Describes the appearance and arrangement of epidermal cells adjacent to stomata.

#	Code	Character State	Description
1	E-14.1	anomocytic	Cells adjacent to the guard cells look like other epidermal cells.
2	E-14.2	anisocytic	Stomata enclosed by 3 cells which may be unequal in size.
3	E-14.3	cyclocytic	Stomata enclosed by a ring of small cells.
4	E-14.4	amphicyclocytic	Stomata enclosed by a double ring of small cells.
5	E-14.5	actinocytic	Stomata enclosed by a ring of larger or radially elongated cells.
6	E-14.6	paracytic	Stomata enclosed by two or four cells.
7	E-14.7	brachyparacytic	Stomata are flanked laterally by two cells.
8	E-14.8	paratetracytic	Stomata enclosed by two elongated cells laterally and two polar cells.
9	E-14.9	anomotetracytic	Stomata enclosed by four irregular cells.
10	E-14.10	other	None of the patterns above.

### E-15. Abaxial cuticle stoma orientation

Describes the orientation of the stomata with respect to the long axis of the leaf.

#	Code	Character State	Description
1	E-15.1	random	Stomata are arranged randomly.
2	E-15.2	sub-parallel	Stomata are arranged almost parallel to each other.
3	E-15.3	parallel	The long axis of stomata oriented parallel to the long axis of the leaf.

#### E-16. Abaxial cuticle stoma distribution

Describes whether stomata are arranged in groups or not.

#	Code	Character State	Description
1	E-16.1	ungrouped	Stomata are single, not grouped.
2	E-16.2	grouped	Stomata are arranged in groups.

#### E-17. Abaxial cuticle stoma position relative to epidermis

Describes whether stomata are raised, sunken or at the same level of the epidermis.

#	Code	Character State	Description
1	E-17.1	raised	Stomata are raised above epidermis level.
2	E-17.2	at the epidermis level	Stomata are at the same level of the epidermis.
3	E-17.3	sunken	Stomata are sunken below the epidermis.

#### E-18. Abaxial cuticle stoma shape

Describes the shape of the stomata.

#	Code	Character State	Description
1	E-18.1	roundish	The stomata have a roundish appearance.
2	E-18.2	elliptic	The stomata have an elliptic shape.

#### E-19. Abaxial cuticle guard cells

Describes the appearance of the guard cells.

#	Code	Character State	Description
1	E-19.1	without polar thickenings	The guard cells do not show thickenings at their poles.
2	E-19.2	with polar thickenings	The guard cells show polar thickenings.
3	E-19.2.1	> I-shaped	Polar thickenings are I-shaped.
4	E-19.2.2	> T-shaped	Polar thickenings are T-shaped.

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### **E-20. Abaxial cuticle stomatal ledges**

Describes whether stomatal ledges have a distinct appearance by strong cutinization.

#	Code	Character State	Description
1	E-20.1	weakly cutinised	Stomatal ledges are weakly cutinized and therefore un conspicuous.
2	E-20.2	conspicuous	Stomatal ledges are strongly cutinized and therefore distinct.

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### **E-21. Abaxial cuticle front cavity**

Describes the appearance of the front cavity of the stomata.

#	Code	Character State	Description
1	E-21.1	roundish	Front cavities are roundish.
2	E-21.2	elliptic	Front cavities are elliptic.
3	E-21.3	spindle-shaped	Front cavities are spindle-shaped.

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