P I N E   A D V A N C E D   V E R S I O N

VOICE	IMAGES	REEL
*1. In cool, temporate regions of the world, there are forests of cone bearing trees known as conifers.	PINE FOREST FROM THE AIR	
*2. One group in particular, the pines, is especially familiar and comprises one of the most extensively traded crops.		
2a. Pollen plays an important role in pine reproduction and we know that it is released from small cones, called pollen cones.	REAL CONE RELEASING POLLEN	
	The pollen cone and microsporangia	
VOICE	IMAGES	REEL
3. The pollen cone consists of many small scale-like parts arranged in numerous spirals.	ANIMATION: ENTIRE CONE Cone model rotating	
4. Each scale in a single spiral is called a **sporophyll** and is attached to the central cone axis.	POLLEN CONE: single spiral	
5. On the underside of each sporophyll there are two **microsporangia.**	MICROSPOROPHYLL: rotation	
6. An outer epidermis covers the sporophyll and its sporangia	MICROSPOROPHYLL: outer layer epidermis sliding off to the right and left	
7.	MICROSPOROPHYLL: remove one microsporangium	
8. Beneath the subepidermal tissue there is a layer of cells known as the **tapetum.** The **tepatum** tissue contributes to the development of the pollen grains.	MICROSPORANGIUM: remove all external layers	

9. Inside of the tapetum, there is a mass of spore-producing cells called **microsporocytes.**	MICROSPORANGIUM: slice into sporocytes	
10.The nucleus of a sporocyte cell is diploid, containing two sets of chromosomes, one from each parent.	MICROSPORANGIUM: move in on to sporocyte cells	
11. As each sporocyte prepares to divide, it deposits a layer of inert **callose.** Callose effectively isolates the microsporocytes from one another	SPOROCYTE CELLS: callose	

	MICROSPORE AND POLLEN GRAIN FORMATION	
VOICE	IMAGES	REEL
12. The nucleus inside each sporocyte divides by **meiosis** to produce four haploid daughter nuclei.	MICROSPOROCYTE: INSIDE Splitting open the cell and rotating.	
13.	MICROSPOROCYTE: meiosis Nucleus dividing	
14. Each nucleus becomes surrounded by a wall that begins to enlarge at two points.	MICROSPOROCYTE: four nuclei	
15. The resulting **microspore cells** remain attracted to one another and are known as a **tetrad.**	MICROSPOROCYTE: wall formatio	
16.	MICROSPORE: appearance of wings	
17. The wall outgrowths develop into enlarged , gas-filled structures called **wings.**	MICROSPORE: wing enlargement	
18. The individual microspores now increase in size.	MICROSPORES: separation	
19. At this stage, a microspore consists of two large, expanded wings and a smaller, dome-shaped portion.	MICROSPORE: intact, exterior view Motion: camara swings around to one microspore	
20. The dome-shaped portion contains one of the spore cells from the original tetrad, complete with haploid nucleus and surrounding cytoplasm.	MICROSPORE: cut apart	
21. Three successive mitotic divisions now take place. These create two small **prothallial cells,** one **generative cell** and one **tube cell.**	MICROSPORE: mitotic divisions	

22. These cells represent the immature male gametophyte. This entire structure, consisting of the external wall and the male gametophyte, is known as the **pollen grain.**	POLLEN GRAIN: halves coming tog	
23. A final deposit of sporopollenin completes the formation of the pollen grains and they are released when the microsporangium opens.	POLLEN GRAIN Final deposit of sporopollenin	
24.	POLLEN GRAIN: release Sporangium opening	
25. The pollen grains are now easily dispersed by air currents.**.**	REAL SHOOT TIP WITH CONE Pollen being blown away.	

	THE OVULATE CONE **AND POLLINATION**	
VOICE	IMAGES	REEL
26. Seeds play an important role in the reproduction of pine and we know that they are released from large, woody cones.	OLDER SHOOT Close up of woody a cone.	
27. However, when these cones first appear in the spring time, they are small and fleshy. At this stage they contain ovules, and are called **ovulate cones**	YOUNG SHOOT TIP, YOUNG OVULATE CONE Young stem with a cluster of 1st year ovulate cones	
28. The intact ovulate cone consists of numerous spirally arranged **ovuliferous scales**.	**ANIMATION** FADE OVER FROM REAL TO MODEL CONE	
29. Each ovuliferous scale has a small **bract** fused to its lower surface.	OVULATE SCALES: entire cone, then removing all but one spiral of ovuliferous scales.	

30. The upper surface contains two ovules. Each ovule has an outer protective layer or **integument**. An opening in the integument, the **micropyle,** consists of a canal that terminates in two micropylar arms, each covered with a sticky secretion. Beneath the integument there is a fleshy **megasporangium** containing a diploid, **megasporocyte** cell.	SINGLE OVULIFEROUS SCALE: Fly around to show top surface of ovuliferous scale. Move in close. Move up to micropyle Add stick drops Remove integument covering. Remove sporangium covering	
31. When the cone is ready to receive pollen, the ovuliverous scales separate from one another, exposing the ovules inside.	OVULATE CONE: Scales parting.	
32. Carried by air currents, some pollen grains are forced between the ovuliferous scales and fall down toward the ovules.	POLLEN GRAINS: Pollen arriving in the sky, then being blown up against the ovulate cone Pollen falling down inside the cone	
33. Some of the pollen grains adhere to the sticky suface of the micropylar arms.	OVULE: Micropyle with sticky drops. Pollen arriving and sticking to drops.	
34. The megasporangium now releases a fluid called the **pollination drop**. As this fills the micropyle, it picks up the pollen grains.	OVULE: pollination drop forming. Ovule opened up to see pollination drop rising in micropyle. Pollen grains on surface, one going into the drop and up micropyle.	
35. The pollination drop soon moves back up the tube, taking the pollen grains to the surface of the megasporangium.	OVULE: pollination drop receding. Pollination drop shrinking down to surface of megasporangium. Pollen grains on sporangium surface.	
36. At this time, the micropylar arms wither, effectively sealing the pollen grains inside the ovule.	OVULE: closure of the micropyle Camera pulls back; lid back on the integument. Micropyle arms withering.	
37. The scales of the cone now grow together, sealing the ovules inside a tough protective barrier.	OVULATE CONE: closing	

	GAMETOPHYTE DEVELOPMENT	
VOICE	IMAGES	REEL
38. Inside the ovule, on the surface of the megasporangium, the pollen grain begins to swell and form a tube-like growth.	MEGASPORANGIUM SURFACE: pollen grain Move in close to a single pollen grain.	
39. The **generative cell** remains inside the pollen grain while the **tube cell** directs the growth of the pollen tube.	MEGASPORANGIUM SURFACE: Tube growth commences into lthe sporangium .	
40. The generative cell soon divides, forming a **sterile cell ....** and a **spermatogenous cell.** Both of these then move into the growing pollen tube.	GENERATIVE CELL: the generative cell dividing Interior of pollen grain-tube to see cells. Put exterior back on to grain-tube.	
41. Inside the megasporangium, the single **sporocyte** cell divides by meiosis to produce four haploid **megaspores.**	MEGASPORANGIUM: Cut-away of sporangium. Camera swings to middle to see sporocyte cell.	
42. However, three of these degenerate.	MEGASPORES: three shown degenerating	
43.The surviving megaspore enlarges and its nucleus divides many times, but no walls are formed. It is now the end of the first growing season.	MEGASPORE NUCLEUS: Megaspore becoming transparent. Repeated divisions Surface of megaspore	
	The Second growing season.	
44. With the passing of winter, growth resumes and walls are formed in what is now the female gametophyte.	FEMALE GAMETOPHYTE Surface cut out and Regular rows of cells Lid of megaspore	

45. At the micropylar end of the gametophyte, everal pores form. . Each of these leads to an **archegonium**.	ARCHEGONIA: Fade in of 2-3 archegonia at micropylar end	
46.	ARCHEGONIUM: Fade away of female Three archegonia shown in 3D, front and then one **TRY TO BRIGHTEN UP EGG CASES**	
47. At the entrance of an archegonium, there are several rings of **neck cells**. Inside, there is a large basal **venter** containing a single **egg** cell.	ARCHEGONIUM: highlighting parts Neck, neck cells Venter, x-ray of egg inside Venter surface view again Return lid to female tissue Reutn lid to surrounding sporangium. Camera moves back to whole ovule on ovuliferous scale.	

	FERTILISATION	
VOICE	IIMAGES	REEL
48. Early in the second year, the pollen tube grows through the megasporangium to the female gametophyte.	POLLEN TUBE: Ovules on scale Camera moves in Lid to sporangium comes off A pollen tube heading towards one archegonium	
49. As the pollen tube approaches an archegonium, the spermatogenous cell divides to produce two **sperm** cells.	SPERM CELLS: Close up of tube tip, x=ray to show division of spermatogenous cell	
50.	POLLEN TUBE: Pollen tube entering pore. Dissolve female tissue; two neck cells and tube going into them.	
51. Reaching the archegonium, the tip of the pollen tube forces itself between the neck cells and into the egg.	POLLEN TUBE: Tube entering egg cell	

52. The tube nucleus, two sperm cells and the sterile cell are now released into the egg cytoplasm. One sperm nucleus fuses with the egg nucleus to create a diploid **zygote**.	FERTILISATION Tube nucleus, sterile cell and sperm cells entering egg. Sperm joins egg nucleus. Camera moves back into sporangium.	
53. Adjacent archegonia may also be fertilised if more than one pollen grain is present. The female gamatophyte may therefore contain several zygotes.	MULTIPLE FERTILISATION: A second pollen tube seen going through sporangium and entering an archegonium concavity.	
54. At the time of fertilisation, the ovule therefore consists of several **archegonia**....inside a **female gametophyte**.....which sits inside a **megasporangium.** The **male gametophyte** has grown through the megasporangium to reach an egg. This is all enclosed within the **integument** of the ovule.	OVULE: SLOW DOWN !!!!! Three archegonia (stop) Female gametophyte (stop) megasporangium (stop) Pollen tubes, cut away integument, cut away pull back and lid of sporangium back.	
	EMBRYO AND SEED FORMATION	
VOICE	IMAGES	REEL
55. Protected inside the ovule, the fertilised eggs are now ready to form embryos.	OVULE GOING INSIDE: SLOW DOWN Ovule on scale; ;move in and remove all covers to show zygote	
56. The diploid zygote nucleus undergoes two mitotic divisions and the 4 nuclei migrate to the base of the archegonium	FIRST AND SECOND DIVISIONS Zygote divisides twice. Nuclei migration.	
57. Successive divisions result in a 16 celled embryo. The tier of 4 cells at the base of the archegoniuim are **embryo initials**. The 4 cells of the adjacent tier are **suspensor inititials**.	FOURTH & FIFTH DIVISION: Four nuclei divide twice 16 nuclei. Walls forming and differentiation of two sets of initial cells.	

58. The suspensor initials elongate, first pushing the embryo initials up against the wall of the archegonium................	SUSPENSOR INITIALS: elongation taking place Showing the suspensors elongating within the archegonium	
59. ....and then out into the female gametophyte....................	SUSPENSORS PUSHING OUT OF ARCHEGONIUM Apical initials/embryos in female tissue	
60. ....where breakdown of the adjacent tissue creates a **corrosion cavity**.	CORROSION CAVITY FORMING	
61. The four initial cells separate and each begins to form an **embryo** and additional **suspensor** cells which push them further into the female gametophyte	EMBRYOS Suspensors pushing four embryos into the female gametophyte.	
62. Intense competition between the four young embryos for nutrients and space results in only one embryo surviving.	EMBRYO COMPETITION: Embryo competition. Growth of all four embryos with one enlarging and the others diminishing in size and lagging behind.	
63. Embryo systems in adjacent archegonia proceed through the same stages of growth and competition. Soon, however, one young embryo dominates and proceeds to develop further, while the remainder abort.	ADJACENT ARCHEGONIA: three archegonia, the embryo of one dominating those of the others	
64. This surviving embryo enlarges and develops a shoot **apical meristem** surrounded by a circle of seed leaves called **cotyledons**.	COTYLEDONS: development Appearance of tiny bumps around apex.	
65. Below the cotyledons, the embryo forms an elongated cylinder of cells that represents the stem-to-root axis. A protective **root cap** covers an **apical meristem**.	MATURE EMBRYO Embryo elongating to show cylinder with all its parts. Camera moves around to tip to show the root.	
66. Nutrients now begin to accumulate in the surrounding female gametophyte.	NUTRIENT CONTENT Accumulation of nutrients	
67. Water is removed and the seed enters a resting or dormancy stage.	WATER CONTENT Removal of water Female changes colour and texture Lid back on the integument	

68. Seed maturation is also accompanied by the transformation of the integument into a tough, protective **seed coat**.	SEED COAT Integument changing into the seed coat, going brown. Ovuliferous scale with two seeds.	
69. The seed and surface tissue separate from the cone scale forming a winged seed. Cone opening and seed release usually take place in the autumn of the second year.	SEED RELEASE Dissolve of scale to show wings with attached seeds.	

	SEED GERMINATION	
VOICE	IMAGES	REEL
70. When a seed is released from the cone and absorbs water, it is ready to germinate.	SEED: a seed located on moist soi Surface view of waster puddle Lid removed to see water particles going inside to the female tissue	
71. Nutrients stored within the female gametophyte are now absorbed by the cotyledons for use by the growing embryo.	NUTRIENTS: mobilisation of female gametophyte reserves Particles leaving female and going into cotyledons.	
72. The root, protected by the cap, grows into the soil to provide water and support for the stem.	ROOT: showing the primary root emerging from the seed Root entering the soil.	
73. Soon, the stem axis below the cotyledons, known as the **hypocotyl,** begins to elongate.	HYPOCOTYLE: Lid of seed coat removed. Stem and cotyledons begining to elongate	

74. Continued hypocotyl elongation lifts the cotyledons out of the soil. When the seed coat is shed, the cotyledons expand and become green and photosynthetic.	EMERGENCE: showing the hypocotyl appearing above the soil and cotyledons greening Seed coat coming off. Cotyledons bending upward and greening. Cotyledons expending outward.	
75. The short stem above the cotyledons, the **epicotyl,** begins to grow and to form leaves.	SEEDLING: Stem above cotyledons growing upwards.	
76.The seedling then develops into another cone-bearing tree.	SEEDLING: continued upward growth	
F I N A L E		
With over 500 species, cone bearing seed plants have successfully adapted to many different habitats around the world.. The pollen grain has enabled these plants to evolve a form of internal fertilisation, breaking the dependence upon water to carry the sperm to the egg. The seed, containing an embryo and source of nourishment, has replaced the spore as a means of dispersal. . This combination of features has contributed to the success of these plants, which include the tallest, largest and longest-living plants known.	LIVE FOOTAGE: Young pine tree Close, then pull back to tree in grassy area.	